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Subjects

BULLETIN No. 25—NEW SERIES.

U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF ENTOMOLOGY.

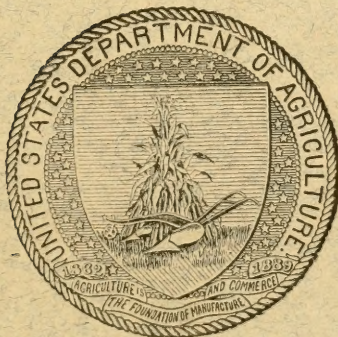
NOTES

ON

THE MOSQUITOES OF THE UNITED STATES:

GIVING SOME ACCOUNT OF THEIR STRUCTURE AND BIOLOGY,
WITH REMARKS ON REMEDIES.

BY

L. O. HOWARD, PH. D.,
Entomologist.WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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DIVISION OF ENTOMOLOGY.

Entomologist: L. O. Howard.

First Assistant Entomologist: C. L. Marlatt.

Assistant Entomologists: Th. Pergande, F. H. Chittenden, Frank Benton.

Investigators: E. A. Schwarz, D. W. Coquillett.

Assistants: R. S. Clifton, Nathan Banks, F. C. Pratt, Aug. Busek, Otto Heidemann,

A. N. Caudell, J. Kotinsky.

Artist: Miss L. Sullivan.

LETTER OF TRANSMITTAL

U. S. DEPARTMENT OF AGRICULTURE,

DIVISION OF ENTOMOLOGY.

Washington, D. C., July 24, 1900.

SIR: I have the honor to transmit herewith manuscript of a bulletin on the mosquitoes of the United States, which gives some account of their structure and biology and indicates the differences in all stages of existence between the kinds of mosquitoes which have been shown to transmit malaria and those which do not. It also treats of the subject of remedies in considerable detail. It has been written mainly from the popular standpoint, although scientific details of structure and classification have been inserted for the use of physicians engaged in studying malaria. I recommend that it be published as Bulletin No. 25, New Series.

Respectfully,

L. O. HOWARD,

Entomologist.

Hon. JAMES WILSON,

Secretary of Agriculture.



INTRODUCTION.

A number of articles and notes concerning mosquitoes have been published in different bulletins of this Division. The most extensive was the leading article in Bulletin No. 4, New Series ("The Principal Household Insects of the United States"), and constituted the larger part of chapter 1, on "Mosquitoes and Fleas." In this treatment of mosquitoes the complete life history of *Culex pungens* was given, based upon original observations made in the summer of 1895, and some general remarks on the subject of other species were brought together. Four pages were devoted to the subject of remedies, and the mosquitoes of the country at large were tabulated, with such notes on geographical distribution as could be brought together. The earlier notes published by the Division, including those extracts from correspondence and general notes which had been published in the seven volumes of Insect Life, and the writer's two articles on the use of kerosene against mosquito larvæ, were all digested in this bulletin, which was published in the summer of 1896. Subsequent brief notes on remedies have been published by the writer in miscellaneous bulletins of the Division and in the Scientific American, and the life history of *Anopheles quadrimaculatus* was described, in comparison with that of *Culex pungens*, in a short illustrated article in the Scientific American for July 7, 1900.

The writer first became interested in mosquitoes thirty years or more ago, when as a boy he fished and collected insects in the marshes at the head of Cayuga Lake, New York, and as early as 1867 had experimented with the kerosene remedy against mosquito larvæ in a horse trough at Ithaca. In 1881 he discussed with Dr. A. F. A. King and the late C. V. Riley the bearings of the theory, which Dr. King was the first to bring forward in the United States, of the probable relation between mosquitoes and malaria, both Dr. Riley and the writer contending, it must be confessed, that the arguments brought forward by Dr. King in conversation were based upon coincidental observations, and afforded no good proof of cause and effect.

The writer's practical demonstration in 1894 of the value of the kerosene treatment as a practical large-scale remedy attracted considerable attention to the subject of remedies for mosquitoes, and many large-scale experiments were made, some of them being successful to a marked degree, as will be pointed out later in the section on remedies. The services of the members of this office force were called

into requisition on a number of occasions to determine actual breeding points in mosquito-infested regions, and interest in the subject gradually increased until, during the past two or three years, the researches of those medical men, whose names have since become so well known in this connection, showed by exact methods that Dr. King's theory must no longer be considered a theory but a demonstrated fact. It has resulted that the attention of the entire civilized world has been drawn with vivid interest toward the whole mosquito question. Every fact concerning mosquitoes becomes now of great potential importance. The correspondence of this office on mosquitoes, owing largely to its publications, has become greatly increased. The writer has been invited to address scientific bodies and citizens' improvement associations on the subject of mosquito extermination, and in the spring of the present year lectured before the annual meeting of the Royal Society of Canada and before the section on theory and practice of medicine of the American Medical Association on the subject of the biology of the mosquitoes of the genus *Anopheles* as contrasted with that of the mosquitoes of the genus *Culex*. The demand for the publications of this Division on mosquito subjects has been so great that it has been deemed desirable to bring together the published and unpublished articles and notes in convenient reference form from the standpoint of the United States only, and this has been done in the present bulletin.

The writer is indebted to his assistants, Mr. D. W. Coquillett, for determinations of the different mosquitoes discussed; Mr. F. C. Pratt, for untiring efforts in the collection of material; Mr. August Busck, Mr. R. S. Clifton, and Mr. J. Kotinsky, for assistance in laboratory experiments, and Miss L. Sullivan, for the preparation of the illustrations. Information and specimens derived from many correspondents are acknowledged in the pages of the bulletin.

L. O. H.

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NOTES ON THE MOSQUITOES OF THE UNITED STATES.

ON MOSQUITOES IN GENERAL.

Abundance of mosquitoes.—The literature of popular entomology is full of instances of the enormous numbers in which mosquitoes occasionally occur. Persons interested in this line of curious reading should consult Kirby and Spence's *An Introduction to Entomology*, Volume I, pages 112-120, and Frank Cowan's *Curious Facts in the History of Insects*, pages 278-286. Referring to their occurrence in the far northern regions, Kirby and Spence, for example, say: "In Lapland their numbers are so prodigious as to be compared to a flight of snow when the flakes fall thickest or to the dust of the earth. The natives can not take a mouthful of food or lie down to sleep in their cabins unless they be fumigated almost to suffocation. In the air you can not draw your breath without having your mouth and nostrils filled with them, and unguents of tar, fish grease, or cream, or nets steeped in fetid birch oil are scarcely sufficient to protect even the case-hardened cuticle of the Laplander from their bite." Elsewhere the same authorities say: "In the neighborhood of the Crimea the Russian soldiers are obliged to sleep in sacks to defend themselves from the mosquitoes, and even this is not a sufficient security, for several of them die in consequence of mortification produced by the bites of these furious bloodsuckers." Elsewhere: "And Captain Stedman, in America, as a proof of the dreadful state to which he and his soldiers were reduced by them, mentions that they were forced to sleep with their heads thrust into holes made in the earth with their bayonets and their necks wrapped round with their hammocks." Humboldt says: "Between the little harbor of Higuerote and the mouth of the Rio Unare the wretched inhabitants are accustomed to stretch themselves on the ground and pass the nights buried in the sand 3 or 4 inches deep, leaving out the head only, which they cover with a handkerchief." Theodoretus says that Sapor, King of Persia, was compelled to raise the siege of Nisibis by a plague of gnats, which attacked his elephants and beasts of burden and so caused the rout of his army.

In modern times nearly every hunter and fisherman in this country has had experience with mosquitoes which renders easy of belief all of the old-time stories. The instance mentioned in Bulletin No. 4, of

the observations by Mr. Schwarz, of this office, at Corpus Christi, Tex., could be practically duplicated by many persons. He showed that when the wind blows from any other direction than south "hundreds of thousands of millions" of mosquitoes blow in upon the town. Great herds of hundreds of horses run before the mosquitoes in order to get to the water. With a change of wind, however, the mosquitoes blow away. Many regions, especially along the seacoast, have been actually rendered uninhabitable by the abundance of mosquitoes, and they have been a serious drawback to the settlement of many otherwise advantageous and fertile localities.

Dr. Otto Lügger reports, on pages 216, 217 of his annual report for 1896 as entomologist to the Minnesota State Agricultural Experiment Station, an interesting series of observations to determine the number of mosquitoes which may be bred in an ordinary rain barrel. The observations were made at St. Anthony Park, Minnesota. On July 6, 1896, the water in one barrel was filtered and was found to contain 17,259 eggs, larvæ, and pupæ. On July 22, 1896, by a similar process, 19,110 mosquitoes were counted. When we consider that at least twelve generations may breed in a summer it is obvious, from Dr. Lügger's account, that a neighborhood may be well supplied from one neglected rain-water barrel.

Alaskan and other far northern mosquitoes.—Since the opening up of the gold fields in Alaska and the great influx of miners and traders, knowledge of the abundance and ferocity of the Alaskan mosquitoes has become widespread, and surveying parties from the United States Coast and Geodetic Survey and the United States Geological Survey in starting for Alaska for their summer's work are in the habit of consulting this office for the best remedies for mosquito bites. Those who were in Alaska the preceding year always state that they never experienced or even imagined anything in the mosquito line quite equal to those found in our northern territory. Mr. W. C. Henderson, of Philadelphia, who spent some time in Alaska recently, writes: "They existed in countless millions, driving us to the verge of suicide or insanity." Nothing has as yet been published regarding the exact species found in Alaska, but Mr. Coquillett has determined *Culex consobrinus* and *Culex impiger* from specimens collected by Prof. Trevor Kincaid on the Harriman expedition of 1899. *C. consobrinus* was collected at Sitka June 16, and Yakutat June 21; and *C. impiger* was taken at Sitka June 16, Yakutat June 21, Virgins Bay June 26, and Popoff Island July 8-16.

That the knowledge of the existence of mosquitoes in boreal regions is not new is shown by the quotation just made from Kirby and Spence, and in Bulletin No. 4 the writer mentioned some of the instances of record by arctic explorers, citing, for example, the narrative of C. F. Hall's second arctic expedition, in which the statement is made that

mosquitoes appeared on the 7th of July, 1869, in extraordinary abundance, and of Dr. E. Sterling, of Cleveland, Ohio, who sent us an account of the appearance of mosquitoes by thousands in March, 1844, when he was on a snowshoe trip from Mackinaw to Sault Ste. Marie. Their extraordinary appearance at that season of the year was remarkable as indicating a most plentiful hibernation. Mr. H. Stewart, of North Carolina, was also quoted as noticing, on the north shore of Lake Superior, in 1866, in the warm days of March, when the snow was several feet deep and the ice on the lake 5 feet in thickness, that mosquitoes appeared in swarms, "literally blackening the banks of snow in the sheltered places." Dr. Otto Lugger was also quoted as stating that *Culex consobrinus* made its appearance in April, 1896, at St. Anthony Park, Minnesota, in a genuine swarm with a heavy snow-storm, at a time when all the lakes were covered with ice.

Dr. Lugger has also called the writer's attention to the fact that Dr. Emile Bessels, of the *Polaris* expedition, was obliged to interrupt his work in Davis Straits (latitude 72° N.) on account of the multitude of these insects.

Length of life of the adult mosquito.—A curious and as yet unexplained point in regard to a phase of mosquito existence is their extraordinary abundance at certain times upon dry prairies miles from water, which has led to the very generally accepted idea among far Westerners that all mosquitoes do not need pools of stagnant water in which to breed, but that certain of them must have some other breeding habit. This supposition still appears incredible to the writer, who is much more inclined to attribute this abundance in dry regions to a greater longevity on the part of the adult mosquitoes of certain species than has been proven, thus enabling these great swarms to live from one rainy spell to another, no matter how widely separated. The gravid females of most insects seem to be able to live until they have opportunity for appropriate oviposition. The writer is frequently asked as to the duration of the adult stage of mosquitoes, but beyond the statement that although adults hibernate, living in this condition from November until April or May in the latitude of Washington, he is obliged to state that they die rather quickly in confinement in the summer. He has had living specimens of *Anopheles quadrimaculatus* confined in breeding jars for eight days, all dying, however, at the expiration of that time. Dr. Woldert has kept adults for fifteen days in a wide-mouthed bottle in which was placed a small slice of banana, the gauze with which the bottle was covered being sprinkled every day. Other specimens were kept from fifty to sixty days, but this was in the late fall, and many of them would probably have hibernated. Dr. Manson states that they may be kept for weeks in a glass vessel containing a piece of ripe banana, the banana being renewed every three or four days.

Life history of mosquitoes in general.—In general terms the biology of the Culicidae—the family to which the true mosquitoes belong—may briefly be summed up. All general statements heretofore have been based upon the life history of one or two species of the genus *Culex*, yet it is certain that such remarks will not only not hold for the whole family, but that, except in a general way, they will not hold for all the species of *Culex*. So far as is definitely known, the larvae of all mosquitoes are aquatic, although they are true air breathers; that is to say, they must come to the surface of the water to breathe. They are rapid breeders and pass the pupal condition also in water, but floating normally at the surface. They pass through several generations in the course of a year and hibernate as adults. Hibernating mosquitoes may frequently be found during the winter months in barns and in the cellars and cold garrets of houses. Dr. W. S. Thayer, of Baltimore, informs the writer that he found *Anopheles crucians* and *A. quadrimaculatus* hibernating in enormous numbers in barns near New Orleans, clustering under the roofs and on the walls. In the extreme Southern States many mosquitoes are active all through the winter, and mosquito bars are almost as necessary at Christmas time as during the summer.

Food of adult mosquitoes.—It is a well-known fact that the adult male mosquito does not necessarily take nourishment and that the adult female does not necessarily rely on the blood of warm-blooded animals. The mouth parts of the male are so different from those of the female that it is probable that if it feeds at all it obtains its food in a quite different manner from the female. They are often observed sipping at drops of water, and in one instance a fondness for molasses has been recorded.

The writer has already placed on record the instance in which his colleague, Mr. E. A. Schwarz, observed a male mosquito sipping beer, but the most interesting instance of alcoholism of the male mosquito which has come to his notice was described in a letter received last spring from Dr. St. George Gray, of Castries, St. Lucia, British West Indies. Dr. Gray wrote:

"The males, especially *C. pipiens*, are very fond of wine, and almost every day I can catch one or two—always males—on the neck of the decanter or in a wineglass that has just been used. I put a few mosquitoes under a bell jar one day in order to watch them. I put a single drop of port wine under the jar, as I had heard that mosquitoes could be kept alive for a long time on wine. When I went to look at them a few hours later I found them all apparently dead, so I put them in a dry bottle, intending to pin them later. When I went to pin them shortly afterwards they were all staggering about in the most ridiculous manner—they were drunk!"

The female mosquitoes are normally without much doubt plant feeders. Why they should draw blood at all is a question which has not been solved. It has been surmised that a supply of highly nutri-

tive fluid is necessary for the formation of the eggs, but this supposition is at once emphatically negatived by the fact that mosquitoes abound in regions into which warm-blooded animals never penetrate. The statement which the writer has elsewhere made, that not one in a million ever gets the opportunity to taste the blood of a warm-blooded animal, is unquestionably an underestimate. There are in this country enormous tracts of marshy land into which warm-blooded animals never find their way and in which mosquitoes are breeding in countless numbers, and when we get within the Arctic Circle and other uninhabited regions the point is emphasized. Scattered through the seven volumes of *Insect Life* are records of the observation of the vegetarian habit, one writer stating that he has seen mosquitoes with their beaks inserted in boiled potatoes and another that he has seen watermelon rinds with many mosquitoes settled upon them busily engaged in sucking the juice. That they may and occasionally do feed upon other than warm-blooded animals, however, is evidenced by an observation by the late Dr. H. A. Hagen, who mentions taking a species of mosquito in the Northwest which was engaged in feeding upon the chrysalis of a butterfly, while there are several instances on record where they have been observed puncturing the heads of young fish and killing them.

How far will mosquitoes fly?—The question is often asked: "How far will mosquitoes fly from their breeding places, or how far can they be driven by the wind?" In some instances this becomes a matter of practical importance, since, if mosquitoes fly great distances, exterminative work on the breeding places near a house or community will be of comparatively slight avail. There exists on this point a difference of opinion. In a discussion at the meeting of the Association of Economic Entomologists at Boston, in August, 1898, Dr. John B. Smith stated, in referring to the possibility of mosquitoes being carried by strong winds to considerable distances, that he had noticed that they would not rise or take flight when a brisk breeze was blowing, and that even a comparatively slight breeze will keep them from upper stories in houses. He, therefore, doubted the wide distribution of mosquitoes by high winds. Dr. H. T. Fernald stated that at Cold Spring Harbor, Long Island, with a north breeze there are no mosquitoes. With a south breeze, on the other hand, they are often very troublesome, especially after a prolonged gentle wind of five or more hours' duration. There are no pools in the center of the island, and the mosquitoes are supposed to have been carried from the south shore, a distance of some 15 miles. This question became a very practical one to the members of the Richmond County Country Club on Staten Island, in their operations against the breeding places of mosquitoes on the island, since, if a new supply could be carried over by the winds from the New Jersey coast near by, a large portion of their

labor would be wasted. Mr. W. C. Kerr, the originator of the mosquito work at that place, and an excellent observer, is decidedly of the opinion that mosquitoes are not brought over from New Jersey.

Almost everyone must have noticed the habit of mosquitoes of clinging to branches of trees and grasses during a high wind, swarming out in flight as the wind subsides, but there must be instances when they are greatly aided in spreading by such gentle winds as those mentioned above by Dr. Fernald.

In this connection an observation made by Mr. R. M. Reese in Baltimore is significant. He found that by treating the privy vault in his backyard with kerosene, the supply of mosquitoes to the house was greatly reduced, although there were many other breeding places only a little farther removed.

Another significant instance was mentioned by Prof. Herbert Osborn at the Boston meeting of the Association of Economic Entomologists. He said that in dry seasons the small pools within a quarter to a half a mile from the college buildings at Ames, Iowa, dry up and the mosquitoes disappear, in spite of the fact that within about a mile there are large pools which never become dry.

On this point Mrs. C. B. Aaron writes very sensibly as follows (*Dragon Flies ex. Mosquitoes*—The Lamborn Essays, Appleton & Co., 1890, pp. 35–36):

The migration of mosquitoes has been the source of much misapprehension on the part of the public. The idea prevalent at our seaside resorts that a land breeze brings the swarms of mosquitoes from far inland is based on the supposition that it is capable of long-sustained flight and a certain amount of battling against the wind. This is an error. Mosquitoes are frail of wing; a light puff of breath will illustrate this by hurling the helpless creature away, and it will not venture on the wing again for some time after finding a safe harbor. The prevalence of mosquitoes during a land breeze is easily explained. It is usually only during the lulls in the wind at such times that *Culex* can fly. Generally on our coast a sea breeze means a stiff breeze, and during these even the Odonata, and often the robust and venturesome Tabanidæ, will be found hovering on the leeward side of the houses, sand dunes, and thick foliage. In the meadows south of Atlantic City, N. J., large swarms of *Culex* are sheltered in the dense grass or wind-battered tree tops on the off side of the sand dunes. Here, in common with all localities so exposed to searching wind, the trees and large bushes are much stunted in growth and battered down to a flat top and common level by the wind. In these matted branches, dense with the close-clustered foliage, the mosquitoes may be discovered in such numbers as to bring despair to the heart of the student who is plotting their final extermination. While the strong breezes last *Culex* will stick close to these friendly shelters, though a cluster of houses may be but a few rods off, filled with unsuspecting mortals who imagine their tormentors are far inland over the salt meadows. But if the wind dies down, as it usually does when veering, out come swarms upon swarms of the females intent upon satisfying their depraved taste for blood. This explains why they appear on the field of action almost immediately after the cessation in the strong breeze; on the supposition that they were blown far inland, this sudden reappearance would be unaccountable.

Carriage of mosquitoes by railway trains.—The State of New Jersey has an unfortunate reputation in connection with mosquitoes. While

it is undoubtedly true that mosquitoes are very abundant in most parts of the State, that fact does not mean to the writer that in the greater part of the State there are any more breeding spaces or that mosquitoes are any more prolific within the State borders than elsewhere. It does, however, seem to him that there is constant carriage inland from the marshy seacoast of very many mosquitoes, but by this he does not intend to convey the idea that they are carried by wind or that they fly to any great distance inland. There are other means of conveyance, and of these railway trains seem to be very important. All through the summer evenings many trains are started inland from Weehawken, Hoboken, Jersey City, South Amboy, Long Branch, Atlantic City, Ocean City, and Cape May, N. J. Many of the cars, as the writer knows from experience, contain mosquitoes by the hundreds. In this way unlimited quantities of mosquitoes are carried unlimited distances, and, emerging from the cars, will start to breed even in localities where mosquitoes are ordinarily rare, or would be rare under ordinary conditions. In this way even mountain resorts will get their supply of lowland mosquitoes, and with the improvement of railway service and the increase in number of through cars the danger is constantly increasing. The writer knows of one instance in the Catskill Mountains in New York where the infestation of a previously uninfested place could have been brought about in no other way. Through parlor and through baggage cars now run from Jersey City and Weehawken into the heart of the Catskills and through trains from Boston into the White Mountains.

In the same way through cars run from Baltimore into the Blue Ridge, and thus a constant source of supply may be, and undoubtedly is, kept up.

How long can the larvæ live out of water?—At the meeting of the Association of Economic Entomologists above referred to, Dr. Smith asked if it were possible for mosquitoes to breed in mud, and suggested that there was no reason to believe that the actual presence of water was necessary for all mosquito species. The writer has seen a statement from some Californian, which he is unable to place at the present time, to the effect that there is a prevalent belief in some parts of the United States that when a surface pool dries up half-grown larvæ may exist in the drying mud for some time, reviving with a fresh rain. Mr. C. A. Sperry, of Chicago, wrote us early in 1899 and advanced the same theory. He said that experiments made in small vessels had always been very unsatisfactory to him, and that he abandoned that method and sought the natural breeding places for investigation and experiment. Early in July he found a wet-weather pond with mosquito larvæ in it, the pond being nearly dry. In a few days the water was all gone. He examined closely and discovered no dead larvæ. In about a week it rained, and as soon as the rain

stopped he went to the place and found the mosquito larvæ all through the water as lively as ever, and they began to issue as adults about a week from that time. Again he discovered a place where the water had nearly dried up, and hundreds of mosquito larvæ were seen by him on the wet ground. Three days later it rained, and he found the larvæ in the water as lively as ever. In the same way Mr. Benjamin S. Paschall, of Newfield, N. J., has communicated to us observations of his own which indicate to him a possibility that mosquitoes may breed in grass or moist earth.

Experiments made at this office on a small scale in glass vessels have shown that the larvæ of *Culex* will exist for some little time in wet mud, and some of them will successfully transform after water has been added. In no case, however, were we able to revive larvæ in mud from which the water had been drawn off for more than forty-eight hours, and after twenty-four hours only a small proportion of the larvæ revived. An interesting pool has been under observation during the present month. The pool contained a surface area of about 24 square feet, and was fed entirely by rain water and surface drainage, reaching a depth when full of about 1 foot. All through the summer this pool is well stocked with mosquito larvæ. After a somewhat long drought the water was observed on July 18 to have evaporated almost entirely, a small puddle in the center of the cavity, containing only 3 or 4 cubic inches of water, remaining. It was dark in color, owing to the drainage from a manure pile near by, and to the casual observer showed no signs of life. The water in this little puddle was very shallow. On dipping in a coffee strainer, however, it was found to be literally massed with nearly full-grown mosquito larvæ, many hundreds of which had been brought together into this restricted place. The drying continued until there was almost no water left. On the night of the 20th came a heavy rain, followed with a still heavier one on the morning of the 22d. On the 23d the pool was found to be entirely full of water and to contain its usual stock of mosquito larvæ.

This may be safely said to indicate the usual habit of mosquito larvæ in evaporating pools. As the water gradually recedes toward the deepest portion of the excavation, the larvæ recede with it, concentrating themselves at the deepest point, i. e., at the point where the moisture remains longest. Knowing as we do, then, that even in the absence of any free water the larvæ will remain alive in moist mud for from twenty-four to forty-eight hours, it is evident that such a pool as the one described gradually drying would give the appearance of having been practically dried up for some days before the last cubic inch of free water has entirely disappeared. The concentration of many larvæ at this point in the manner which has been described could not fail to give rise to the belief that mosquito larvæ

will exist in the absence of free water for a much longer period than is really the case. In the opinion of the writer, where the mud dries up entirely the mosquito larvæ are necessarily killed, but that they may exist in very wet mud for a longer or shorter time is true.

An interesting observation bearing upon this point has been made by Dr. St. George Gray, of Castries, St. Lucia, British West Indies, and reported in the *Journal of Tropical Medicine*, London, May 15, 1900. He says that on February 7, 1900, he examined a spot where he had obtained larvæ of *Anopheles* a few months before. The pool had been dry for three weeks, hardly any rain having fallen during that time. The surface of the mud at the bottom was cracked and dry, although soft enough under the crust. He put the mud into a clean pickle bottle and put about 3 inches of filtered water over it, but there was no result. He also took some grass from the sides of the pool and put that grass into another pickle bottle, adding 3 inches of filtered water. On the following morning he found a few minute larvæ wriggling about in this bottle. These rapidly grew in size, and he soon had a half dozen healthy looking larvæ in his bottle. On the 21st, a fortnight after he had taken the grass from the sides of the pool, he reared the imago of *Culex tenuitars*. From this observation he argues that some species of *Culex*, at any rate, do not always lay their eggs on the surface of the water, but where they will be washed into the pool by the first heavy rain. Other similar experiments were failures. This record is a very interesting one, but, like all isolated observations, needs verification.¹ It may here be mentioned that Drs. J. W. W. Stephens and S. R. Christophers, in their article on "The distribution of *Anopheles* in Sierra Leone," published in the reports of the malarial committee to the Royal Society (London, July 6, 1900), stated that they were unable to hatch the eggs of *Anopheles* after desiccation on blotting paper for more than forty-eight hours, although they hatched after twenty-four and forty-eight hours' drying, respectively.

The number of species of mosquitoes.—As regards the different kinds of mosquitoes, about 250 species are known, of which only about 30 have been found in the United States. These are divided into 5 different genera, each of which will receive consideration in the following pages. Of the malarial genus *Anopheles*, Mr. F. V. Theobald writes us there are 27 species in the British Museum collection.

MOSQUITOES AND MALARIA.

This is not the place to discuss at length the history of the discoveries which have brought about the very perfect proof that mosquitoes may and do transfer the malaria germ from a malaria patient and

¹Dr. Walter Reed, U. S. A., tells me that Dr. Lazear has just made a similar observation in Cuba.

deposit it in the blood of a healthy person. Those interested are referred to the admirable paper entitled "On the rôle of insects, Arachnids and Myriapods, as carriers in the spread of bacterial and parasitic diseases of man and animals: a critical and historical study," by George H. Nuttall, M. D., Ph. D., published in Volume VIII of the Johns Hopkins Hospital Reports, and to later American summaries, among which may be mentioned that by Dr. W. N. Berkeley in the New York Medical Record for December 23, 1899, by Dr. Albert Woldert in the Journal of the American Medical Association for February 10, 1900,¹ and by Dr. William Britt Burns in the Memphis Medical Monthly for March, 1900. One of the most thorough of the recent reviews will be found in Nature for March 29, 1900, pages 522-527, entitled "Malaria and mosquitoes," a lecture delivered at the Royal Institution of Great Britain on March 2, by Maj. Ronald Ross, D. P. H., M. R. C. S., lecturer in tropical medicine, University College, Liverpool, himself one of the workers whose results contributed most materially to the establishment of definite proof. Another recent account will be found in the Popular Science Monthly for July, 1900, by Dr. Patrick Manson, entitled "Malaria and the malarial parasite." It should be stated here, however, that only the mosquitoes of the genus *Anopheles* have been found to contain the human blood parasites, although it does not appear from the published accounts which have met the writer's eye that any other genera than *Anopheles* and *Culex* have been studied in this connection.

The Italian observers have found that all three species of the human Hamamoebidae are cultivable in *Anopheles claviger* and not only in this but in other Italian species of *Anopheles*, while they, together with Ross and other observers, have failed to cultivate the parasites in *Culex*. The same fact is upheld by the extended observations made in West Africa and in this country so far as observations have been made as yet. The writer, however, wishes to emphasize the point which he made before the American Medical Association on June 6, 1900, that American physicians, especially those in the Southern States, should not delay the investigation of the very large mosquitoes of the genus *Psorophora* and *Megarhinus* from the malarial standpoint. Both of these genera have been figured and described in succeeding pages.

SYNOPTIC TABLES OF THE NORTH AMERICAN MOSQUITOES.

In order to enable the ready determination of our different mosquitoes the writer published in Circular 40, second series, of this office, in February of the present year, a series of tables, drawn up at his request by Mr. D. W. Coquillett, of the office force, comprising (1) a

¹ Dr. Woldert's article contains a good account of the internal anatomy of mosquitoes and describes his methods of dissection.

synopsis of the five genera under which the long-beaked, blood-sucking species known to occur in North America were divided; (2) a synoptic consideration of the species of the genus *Culex*, divided into (*a*) table of the recognized species, specimens of which occur in the National Museum collection, and (*b*) an account of the unrecognized species, which are known only from the literature; (3) a synoptic consideration of the species of the genus *Anopheles*, divided into (*a*) recognized forms, and (*b*) unrecognized forms; (4) a brief description of the only valid known species of the genus *Psorophora*; (5) a synoptic table of the three known species of the genus *Megarhinus*; and (6) a synoptic consideration of the two known species of the genus *Aedes*.

Mr. Coquillett's tables are here reprinted with slight changes:

I.—GENERIC SYNOPSIS.

The following table contains all the genera of the long-beaked mosquitoes known to occur in North America. The males are readily recognized by the antennæ being densely covered with long hairs; in the females the hairs of the antennæ are short and very sparse:

- | | |
|--|---------------------|
| 1. Palpi in the male at least nearly as long as the proboscis; in the female less than one-half as long..... | 3. |
| Palpi in both sexes at least almost as long as the proboscis..... | <i>Anopheles</i> . |
| Palpi in both sexes less than one half as long as the proboscis..... | <i>Aedes</i> . |
| 2. Proboscis straight or nearly so, colors of body brown and yellowish..... | 3. |
| Proboscis strongly curving downward toward the tip, colors bluish or greenish..... | <i>Megarhinus</i> . |
| 3. Legs bearing many nearly erect scales..... | <i>Psorophora</i> . |
| Legs destitute of such scales..... | <i>Culex</i> . |

II.—GENUS CULEX.

(*a*) RECOGNIZED SPECIES.

Males.

- | | |
|---|--------------------------|
| 1. Front tarsal claws bearing a distinct tooth near the middle of the underside of each..... | 3. |
| Front tarsal claws bearing two teeth on the underside of one claw, and one on underside of the other, proboscis destitute of a whitish band near the middle..... | 2. |
| Front tarsal claws with one tooth on underside of one of the claws, none on the other, bases of tarsal joints white, proboscis destitute of a whitish band near the middle..... | <i>fasciatus</i> Fabr. |
| 2. Tarsi distinctly white at bases of the joints..... | <i>excitans</i> Walk. |
| Tarsi not white at bases of the joints..... | <i>consobrinus</i> Desv. |
| 3. Proboscis destitute of a whitish ring near the middle..... | 4. |
| Proboscis with such a ring, ends of tarsal joints white..... | <i>tarsalis</i> Coq. |
| 4. Bases of tarsal joints not white..... | 5. |
| Bases of tarsal joints white..... | <i>stimulans</i> Walk. |
| 5. Petiole of submarginal cell less than one-third of the length of that cell..... | <i>pungens</i> Wied. |
| Petiole of submarginal cell at least one-half of the length of that cell..... | <i>impiger</i> Walk. |

Females.

- | | |
|---|----|
| Front tarsal claws bearing a distinct tooth near middle of underside of each..... | 2. |
| Front tarsal claws destitute of teeth..... | 7. |

2. Proboscis destitute of a white ring near the middle 3.
 Proboscis marked with such a ring, bases of tarsal joints white. *teniorhynchus* Wied.
3. Bases of tarsal joints distinctly white 4.
 Bases of tarsal joints never white 5.
4. Mesonotum marked with four stripes of silvery scales *fasciatus* Fabr.
 Mesonotum destitute of such stripes:
 Fifth joint of hind tarsi white *teniatus* Wied.
 Fifth joint, except its extreme base, dark brown *stimulans* Walk.
5. Last two joints of hind tarsi never white 6.
 Last two joints of hind tarsi snow white *posticatus* Wied.
6. Abdomen marked with a cross band of whitish scales at base of each segment. *impiger* Walk.
 Abdomen never marked in this manner, but with a cluster of whitish scales at front angles of some of the segments *triseriatus* Say.
7. Proboscis marked with a distinct whitish ring near the middle, tarsi white at sutures of the joints 8.
 Proboscis destitute of a whitish ring near the middle 9.
8. Tarsal joints white at bases only *perturbans* Walk.¹
 Tarsal joints white at both ends *tarsalis* Coq.
9. Tarsi white at bases of joints 10.
 Tarsi never white at bases of the joints 12.
10. Mesonotum never marked with stripes of silvery scales 11.
 Mesonotum marked with four stripes of silvery scales, first tarsal joint never marked with a whitish ring near the middle *signifer* Coq.
11. First tarsal joint marked with a whitish ring near middle of each. *everucians* Walk.
 First tarsal joint destitute of such a ring *excitans* Walk.
12. Petiole of submarginal cell less than one-third of the length of that cell. *pungens* Wied.
 Petiole of submarginal cell at least almost one-half of the length of that cell. *consobrinus* Desv.

(b) UNRECOGNIZED SPECIES.

annulatus Schrank. This European species was credited to our fauna by Osten Sacken. The description agrees fairly well with specimens which I have identified as *excitans*, Walker, except that in the latter there is no white ring on the femora toward their apices.

boschi Desv. Probably a rubbed specimen of *pungens*.

nigripes Zett. Black, the legs of the male dark yellow, hairs of pleura of female gray, a band of white scales at base of each segment of her abdomen.

rubidus Desv. The description was apparently founded on a rubbed specimen of *Psorophora ciliata*.

testaceus v. d. Wulp. Is probably a somewhat injured example of *consobrinus*.

incidens Thomson. Is evidently a synonym of *impiger* Walker.

bigoti Bellardi. According to the figure and description, the bands of black scales are at the bases of the abdominal segments; in the recognized species these bands are always at the apices of the segments. In other respects this species must greatly resemble *pungens*.

cubensis Bigot. Apparently founded on a badly rubbed specimen of *pungens*.

frater Desv. This name was proposed for the *Culex fasciatus* of Wiedemann, under the impression that this is not the same species as the one described by Fabricius under the same name. It seems quite certain, however, that the word "proboscis" in Fabricius' description was simply a lapsus for "palpi," and with this emendation the two descriptions agree very well.

mexicana Bellardi. Is evidently a synonym of *posticatus*.

provocans Walker. Is probably a synonym of *stimulans*. In some specimens of this species the light color at the bases of the tarsal joints is very indistinct.

territans Walker. Is apparently a synonym of *pungens*.

¹Mr. F. V. Theobald, after studying Walker's type of *perturbans*, writes us that it has toothed claws in the female.

Our recognized species of *Culex* and their synonyms may be listed as follows, the synonyms indented:

<i>consobrinus</i> Desv.	<i>perturbans</i> Walker.
? <i>annulimanus</i> v. d. Wulp (Anopheles).	<i>posticatus</i> Wied.
<i>impatiens</i> Walker.	? <i>mexicanus</i> Bellardi.
<i>inornatus</i> Williston.	<i>musicus</i> Say.
<i>pinguis</i> Walker.	<i>pungens</i> Wied.
<i>punctor</i> Kirby.	? <i>boscii</i> Desv.
? <i>testaceus</i> v. d. Wulp.	? <i>cubensis</i> Bigot.
<i>excitans</i> Walker.	? <i>territans</i> Walker.
? <i>annulatus</i> Osten Sacken (nec Meigen, etc.).	<i>signifer</i> Coquillett.
<i>exerucians</i> Walker.	<i>stimulans</i> Walker.
<i>fasciatus</i> Fabr.	? <i>provocans</i> Walker.
frater Desv.	<i>taeniorhynchus</i> Wied.
mosquito Desv.	<i>damnosus</i> Say.
<i>taeniatus</i> Wied.	<i>sollicitans</i> Walker.
<i>impiger</i> Walker.	<i>tarsalis</i> Coquillett.
<i>implacabilis</i> Walker.	<i>triseriatus</i> Say.
<i>incidens</i> Thomson.	
? <i>quinquefasciatus</i> Say.	

III.—GENUS ANOPHELES.

(a) RECOGNIZED SPECIES.

1. With a yellowish white spot near three-fourths of the length of the front margin of the wing; scales of last vein white, those at each end black. *punctipennis* Say.
Without such a spot..... 2.
2. Scales of last vein wholly black, palpi wholly black..... *quadrinaculatus* Say.
Scales of last vein white, marked with three black spots, palpi marked with white at bases of last four joints..... *crucians* Wied.

(b) UNRECOGNIZED SPECIES.

The following species which have been credited to our country have not been recognized with certainty; some of them probably do not belong to the present genus, while a few were evidently founded on badly rubbed specimens in which the distinctive characters were therefore wanting:

annulimanus v. d. Wulp. I strongly suspect that this does not belong to the present genus; the description applies fairly well to the male of *Culex consobrinus* Desv.

ferruginosus Wied. This author proposes this name for the species previously described by Say under the name of *Culex quinquefasciatus*, but the description which he gives differs so decidedly from the one published by Say as to give the impression that it is founded on a different species. I strongly suspect that the type of *ferruginosus* is a rubbed example of *Anopheles crucians*, which was described from the same locality. Say's description of his *Culex quinquefasciatus* agrees very well with the species which I have identified as *Culex impiger* Walker.

maculipennis Meigen. I strongly suspect that this European form is identical with our *Anopheles quadrinaculatus* Say, but this point can not be settled definitely at present, owing to the lack of any European specimens for comparison with ours.

nigripes Staeger. This European species should be readily recognized by its unspotted wings.

albimanus Wied. Differs from our other species by the snow-white apices of the tarsi.

Anopheles pictus Loew is evidently a synonym of *A. crucians* Wied.

Our recognized species of *Anopheles* and their synonyms may therefore be listed as follows, the synonyms indented:

<i>crucians</i> Wied.	<i>punctipennis</i> Say.
<i>pictus</i> Loew.	<i>hiemalis</i> Fitch.
? <i>ferruginosus</i> Wied.	<i>quadrinaculatus</i> Say.
	? <i>maculipennis</i> Meigen.

IV.—GENUS PSOROPHORA.

Our single species is of a yellowish color, usually varied with brown, the bases of the tarsal joints white. It is considerably larger than any of our other species of yellowish or brown mosquitoes:

ciliatus Fabr.
conterrens Walker.
molestus Wied.
 ? *rubidus* Desv.

V.—GENUS MEGARITHINUS.

Our three species are among the largest in this family, and are not known to occur north of the District of Columbia. They may be separated as follows:

All tarsi marked with white *rutilus* Coq.
 Hind tarsi alone marked with white *portoricensis* Roeder.
 None of the tarsi marked with white *hæmorrhoidalis* Fabr.

VI.—GENUS AEDES.

Our two species are among the smallest of our mosquitoes, and have a pale brownish ground color. They may be distinguished as follows:

Thorax marked with a median violet blue stripe *sapphirinus* O. S.
 Thorax destitute of such a stripe *fuscus* O. S.

THE BIOLOGY OF CULEX, WITH REMARKS UPON SOME OF THE SPECIES.

It is tolerably certain that the life round of all of the species of the genus *Culex* is practically the same. They will differ more or less in the character of the water in which they preferably breed, and differing in this respect, they will differ also in some degree in their preferred food, which consists of all sorts of aquatic micro-organisms. Down to the time when the writer published his account of *Culex pungens*, in Bulletin No. 4, New Series, of this office, there was not in any published work a thoroughly satisfactory figure of a well-determined species of mosquito from the United States, or of its earlier stages. The statements quoted in the text-books and manuals dated back in general to the time of Réaumur—more than one hundred and fifty years ago. Réaumur's observations were made in the month of May upon a species (*Culex pipiens*) which does not occur in North America, and the observations were all made at Paris, so that statements as to the duration of the insect in any stage would be incorrect even for the same species in a warmer or colder locality. The following account of the life history of *Culex pungens* (fig. 1) is quoted from the writer's bulletin above cited:

Life history of Culex pungens.—The operation of egg laying was not observed, but it probably takes place in the very early morning hours. The eggs are laid in the usual boat-shaped mass, just as those of *Culex pipiens*, as described by Réaumur. We say boat-shaped mass, because that is the ordinary expression. As a matter of fact, however, the egg masses are of all sorts of shapes. The most common one is

the pointed ellipse, convex below and concave above, all the eggs perpendicular, in 6 to 13 longitudinal rows, with from 3 or 4 to 40 eggs in a row. The number of eggs in each batch varies from 200 to 400. As seen from above the egg mass is gray brown; from below, silvery white, the latter appearance being due to the air film. It seems impossible to wet these egg masses. They may be pushed under water, but bob up apparently as dry as ever. The egg mass separates rather regularly, and the eggs are not stuck together very firmly. After they have hatched the mass will disintegrate in a few days, even in perfectly still water.

The individual eggs are 0.7 mm. in length and 0.16 mm. in diameter at the base. They are slender, broader and blunt at bottom, slenderer and somewhat pointed at tip. The tip is always dark grayish brown in

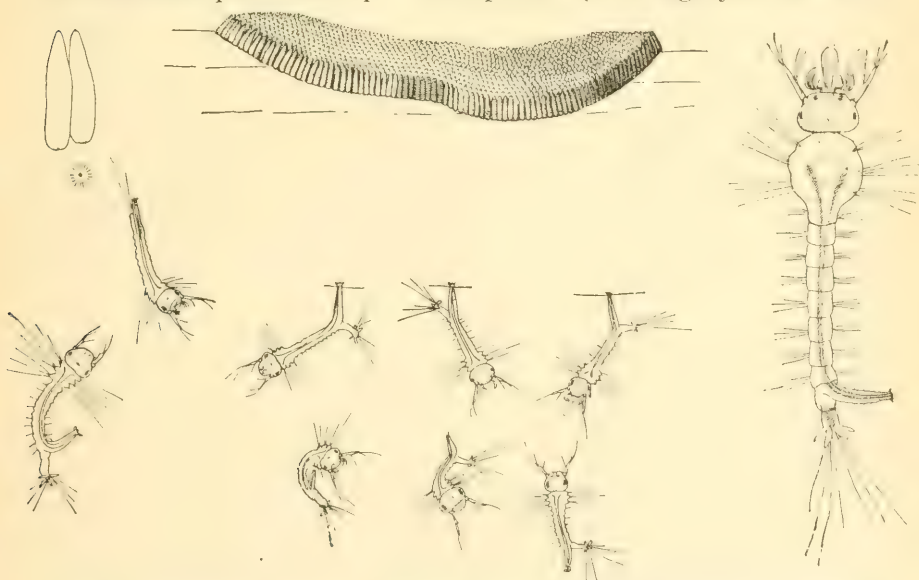


FIG. 1.—*Culicx pungens*: Egg mass, with enlarged eggs at left and young larvæ below—enlarged (original).

color, while the rest of the egg is dirty white. Repeated observations show that the eggs hatch, under advantageous conditions, certainly as soon as sixteen hours. Water buckets containing no egg masses, placed out at night, were found to contain egg masses at 8 o'clock in the morning, which, as above stated, were probably laid in the early morning, before daylight. These eggs, the third week in May, began to hatch quite regularly at 2 o'clock in the afternoon of the same day on warm days. In cooler weather they sometimes remained unhatched until the second day. If we apply the evidence of European observers to this species, the period of the egg state may be under twelve hours; but there is a possibility that they are laid earlier in the night, which accounts for the fact that sixteen hours is the shortest period which we can definitely mention.

The larvæ issue from the underside of the egg masses, and are extremely active at birth. When first observed it is easy to fall into an error regarding the length of time which they can remain under water, or rather without coming to the surface to breathe, since, in striving to come to the surface for air, many of them will strike the underside of the egg mass and remain there for many minutes. It is altogether likely, however, that they get air at this point through the eggs or through the air film by which the egg mass is surrounded, and that they are as readily drowned by continuous immersion as are the older ones, as will be shown later.

One of the first peculiarities which strikes one on observing these newly-hatched larvæ under the lens is that the tufts of filaments which are conspicuous at the mouth are in absolutely constant vibration. This peculiarity, and the wriggling of the larvæ through the water, and

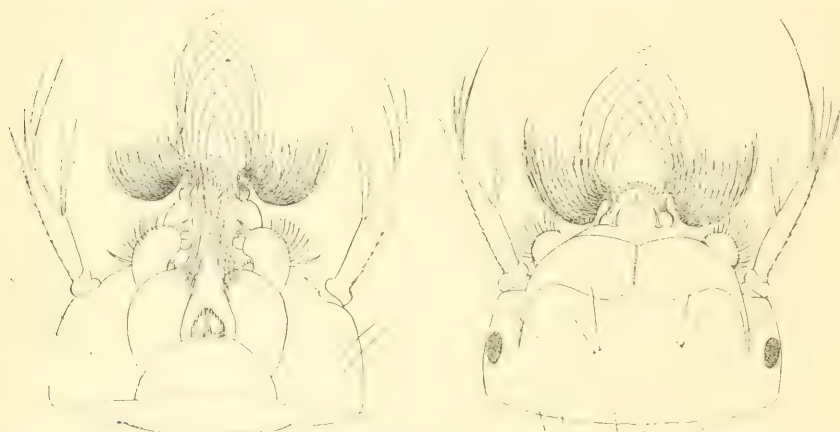


FIG. 2.—*Culicx pungens*: Head of larva from below at left; same from above at right—greatly enlarged (original).

their great activity, render them interesting objects of study. In general the larvæ, passing through apparently three different stages, reach maturity and transform to pupæ in a minimum of seven days. When nearly full grown, their movements were studied with more care, as they were easier to observe than when newly hatched. At this time the larva remains near the surface of the water, with its respiratory siphon at the exact surface and its mouth filaments in constant vibration, directing food into the mouth cavity. Occasionally the larva descends to the bottom, but, though repeatedly timed, a healthy individual was never seen to remain voluntarily below the surface more than a minute. In ascending it comes up with an effort, with a series of jerks and wriggings with its tail. It descends without effort, but ascends with difficulty; in other words, its specific gravity seems to be greater than that of the water. As soon, however, as the respiratory

siphon reaches the surface, fresh air flows into its tracheæ, and the physical properties of the so-called surface film of the water assist it in maintaining its position.

The respiratory tube takes its origin from the tip of the eighth abdominal segment, and the very large tracheæ can be seen extending to its extremity, where they have a double orifice. The ninth segment of the abdomen is armed at the tip with four flaps and six hairs, as shown in fig. 3. These flaps are gill-like in appearance, though they are probably simply locomotory in function. With so remarkably developed an apparatus for direct air breathing there is no necessity for gill structures. Raschke¹ and Hurst² consider that the larva breathes both by the anus and by these gill flaps, as well as by the large tracheæ which open at the tip of the respiratory tube. Raschke considers that these tracheæ are so unnecessarily large that they possess a hydrostatic function. The writer is inclined to believe that the gill flaps may be functional as branchial structures in the young larva, but that they largely lose this office in later life.

After seven or eight days, at a minimum, as just stated, the larva transforms to pupa. The pupa, as has been repeatedly pointed out with other species, differs most pronouncedly from the larva in the great swelling of the thoracic segments. In this stage the insect is lighter than water. It remains motionless at the surface, and when disturbed does not sink without effort, as does the larva, but is only able to descend by a violent muscular action. It wriggles and swims as actively as does the larva, and soon reaches the bottom of the jar or breeding place. As soon as it ceases to exert itself, however, it floats gradually up to the surface of the water again. The fact, however, that the larva, after it is once below the surface of the water, sinks rather than rises, accounts for the death of many individuals. If they become sick or weak, or for any reason are unable to exert sufficient muscular force to wriggle to the surface at frequent intervals, they will actually drown, and the writer has seen many of them die in this way. It seems almost like a contradiction in terms to speak of an aquatic insect drowning, but this is a frequent cause of mortality among wrigglers. This fact also explains the efficacy of the remedial treatment which causes the surface of the water to become covered with a film of oil of any kind. Aside from the actual insecticide effect of the oil, the larvæ drown from not being able to reach the air. The structure of the pupa differs in no material respect from that of corresponding stages of European species, as so admirably figured and described by the older writers, notably Réaumur and Swammerdam³, and needs no description

¹ Raschke, Die Larve von *Culex nemorosus*, Berlin, 1887.

² Hurst, the Pupal Stage of *Culex*, Manchester, 1890.

³ Even Bonanni, in 1691, gave very fair figures of the larva and pupa of a European species. *Micrographia Curiosa*, Rome, MDCXCI, Pars. II, Tab. I.

in view of the care with which the figures accompanying this article have been drawn. The air tubes no longer open at the anal end of the body, but through two trumpet-shaped sclerites on the thorax, from which it results that the pupa remains upright at the surface, instead of with the head downward. There is a very apparent object in this reversal of the position of the body, since the adult insect issues from the thorax and needs the floating skin to support itself while its wings are expanding.

In general, the adult insects issue from the pupæ that are two days

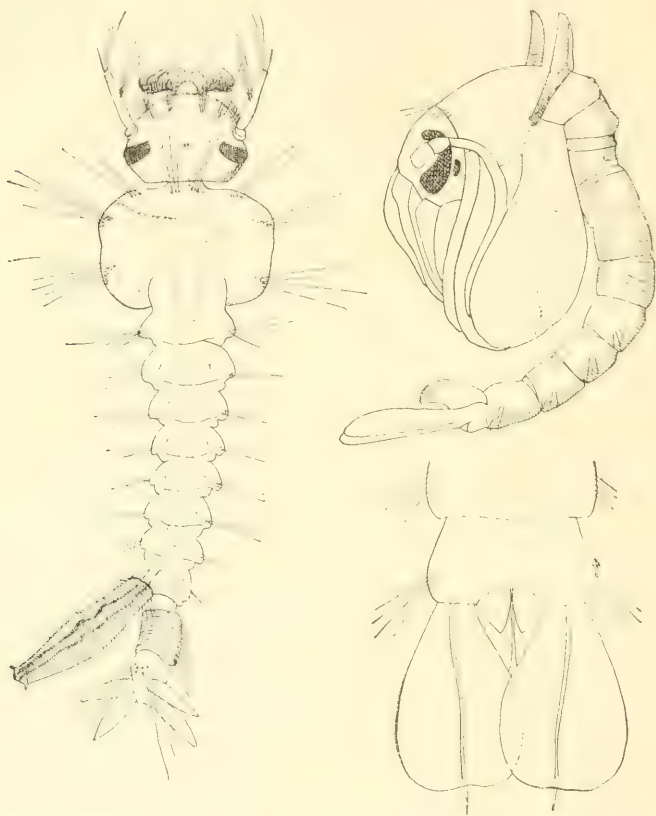


FIG. 3.—*Culicx pungens*: Full-grown larva at left, pupa at right—enlarged (original).

old. This gives what is probably the minimum generation for this species as ten days, namely, sixteen to twenty-four hours for the egg, seven days for the larva, and two days for the pupa. The individuals emerging on the first day were invariably males. On the second day the great majority were males, but there were also a few females. The preponderance of males continued to hold for three days; later the females were in the majority. In confinement the males died quickly; several lived for four days, but none for more than that period. The females, however, lived for a much longer time. Some were kept alive

without food, in a confined space of not more than 4 inches deep by 6 across, for three weeks. But one egg mass was deposited in confinement. This was deposited on the morning of June 30 by a female which issued from the pupa June 27. No further observations were made upon the time elapsing between the emergence of the female and the laying of the eggs, but in no case, probably, does it exceed a few days.

The length of time which elapses for a generation, which we have just mentioned, is almost indefinitely enlarged if the weather be cool. As a matter of fact, a long spell of cool weather followed the issuing

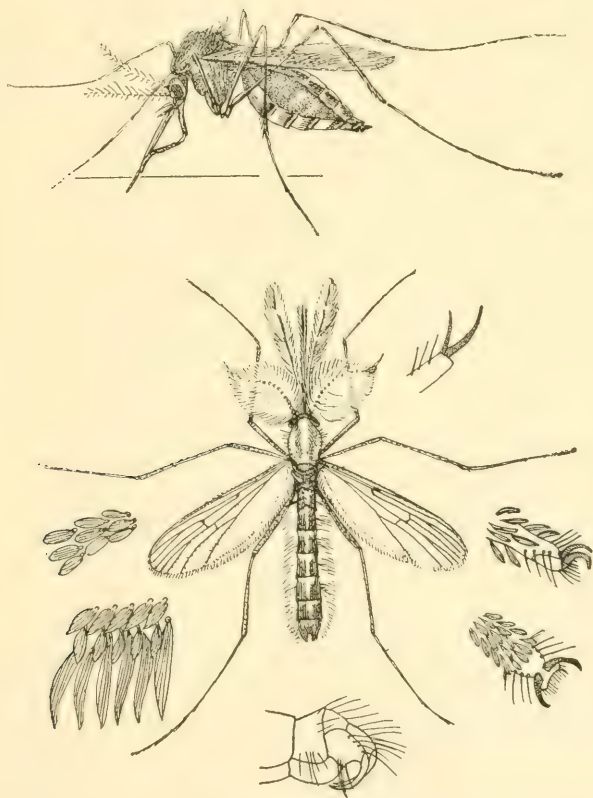


FIG. 4.—*Culicx pungens*; Female above, male below—enlarged (original).

of the adults just mentioned. Larvæ were watched for twenty days, during which time they did not reach full growth.

The extreme shortness of this June generation is significant. It accounts for the fact that swarms of mosquitoes may develop upon occasion in surface pools of rain water, which may dry up entirely in the course of two weeks, or in a chance bucket of water left undisturbed for that length of time. Further, the shortness of this generation was, while not unexpected, not at all in accordance with any

published statements as to the length of life of any immature mosquito of any species. But these published statements, as previously shown, were nearly all based upon observations made in a colder climate and in the month of May.

Remarks on other species of Culex.—The writer is inclined to believe that *Culex tenuiorhynchus* (fig. 5) is more or less specifically the sea-coast mosquito of the Atlantic seaboard; that is to say, it is the mosquito in this part of the country which is able to breed and prefers to breed in the brackish swamps which are occasionally overflowed at high tide. It has been found by Mr. C. W. Johnson at Avalon, Anglesea, and Atlantic City, N. J.; by the writer at Far Rockaway, Amersgansett, and on the beach at Staten Island, New York; by Mr.



FIG. 5.—*Culex tenuiorhynchus*: Female, showing the short palpi which distinguish *Culex* from *Anopheles*; toothed front tarsal claw at right—enlarged (original).

Barber at Chesapeake Beach, Md., and again by Mr. Johnson at St. Augustine and Charlotte Harbor, Fla. Other species, like *Culex pungens*, are seen at seaside resorts, but it is probable that these breed back of the coast in fresh water. This difference in breeding habit is very marked on the east coast of Staten Island. The people there distinguish between the brown-legged mosquitoes and the ring-legged mosquitoes, the former being *C. pungens*, which breeds in the hill ponds and swamps back of the bluffs, and the latter being *C. tenuiorhynchus*, which breeds in the brackish marshes below the bluffs. Dr. A. D. Hopkins states (Bulletin 17, new series, Div. Entom., Dept. Agric.) that what is probably this species apparently breeds in West

Virginia in pools and small streams fed from coal-mine drainage, the water of which contains a large percentage of sulphate of iron.

Culex impiger has been found by Mr. Pratt, of this office, breeding in privy vaults in Alexandria, Va., and this species is likely to be the one found usually in such places where the water is fouled with decomposing or excreted animal matter.

Culex taeniatus is said by Dr. Veazie, of New Orleans, to be the so-called "day mosquito" of New Orleans; that is, the form which flies and bites in the daytime. This statement is corroborated to a certain extent by Dr. St. George Gray, of St. Lucia, British West Indies, who writes, under date of August 12 last:

I have made some observations on the hours at which the different species are most industrious, and find that most mosquitoes have regular feeding times. For instance, *C. taeniatus* is very vigorous and troublesome in the early afternoon (between noon and 3 p. m). Then she usually takes a rest, and renews her attacks at 9 or 10 p. m. During the morning it can be found resting on walls and clothing, particularly dark-colored clothing, and is easily caught.

The distribution of the species of Culex in the United States.—In preparing Bulletin No. 4 the writer was at pains to borrow all of the mosquitoes from the collections of such entomologists as he supposed had saved specimens in this family and placed them in the hands of Mr. Coquillett for study. The material received was not large, since mosquitoes are difficult to preserve satisfactorily in a collection, and it is an inexplicable fact that as a rule collectors do not save such extremely common things as mosquitoes. Yet he was able from Mr. Coquillett's work on the specimens received and on those already contained in the national collection at Washington to show several interesting points. As is the case with many other species of Diptera, most of the different forms were found to be very widespread. The whole group has little or no faunistic value; that is to say, different climatic conditions and other environmental factors do not limit the range of the species as they do with those of other groups. It was thus found that some of the commoner forms, like *C. consobrinus*, *C. excitans*, *C. perturbans*, and *C. posticus*, and *C. pungens*, were found almost all over the country, from New England to Texas and even to southern California, so that in almost any given locality in the United States one would be able to find all of these common species of *Culex*, with two or three species of other genera and possibly two or three other species of *Culex*. Since the publication of the bulletin (No. 4), other localities of distribution have been ascertained, and the following list indicates such actual localities as have come to our notice. Persons interested will observe several points worth noticing in the list which follows. Certain species seem to be rare, while others are very common, in addition to being widespread. It seems from the list that *Culex consobrinus* is a more northern form; that is, it comes nearer being restricted to a boreal habitat than any of the other species. It is one

of the two species which we have from Alaska. The other Alaskan form which has been determined, namely, *C. impiger*, extends south to New Mexico, Georgia, and the island of Jamaica.

Culex tenuitars, according to Mr. Theobald, has a wide tropical and subtropical distribution, occurring in West Africa, India, South Europe, and East and West Indies, but never in the north or south cold temperate zones.

CULEX CONSOBRINUS Desv.

Habitat: White Mountains, N. H.; Beverly, Mass., September 28 (Nat. Mus.); Catskill Mountains, Greene County, N. Y., 2,500 feet (Howard); Illinois, March 21, April 29, May 6, October 16 (Nason); St. Anthony Park, Minn., April, May, on snow (Lugger); Saskatchewan River, British America; South Dakota (Nat. Mus.); Lincoln, Nebr., May, September (Bruner); Colorado (Nat. Mus.); Los Angeles, Cal., February (Coquillett); Argus Mountains, Cal., April (Nat. Mus.); Santa Fé, N. Mex., July (Cockerell); New Orleans, La., November (Thayer); Ottawa, Canada, May (Howard); Summit, N. J. (Holmes); Trenton, Ontario, May 24 (Fletcher).

CULEX EXCITANS Walk.

Habitat: New Bedford, Mass. (Johnson); Lincoln, Nebr., May (Bruner); Santa Fé, N. Mex., July (Cockerell); Laggan, British Columbia (Wickham).

CULEX EXCRUCIANS Walk.

Habitat: Ithaca, N. Y., July 14 (Comstock).

CULEX FASCIATUS Fabr.

Habitat: Georgia, August (Coquillett); Natchitoches, La., October 6 (Johnson); Isle of Pines, West Indies (Scudder); Kingston, Jamaica, July 13 (Johnson); New Orleans, La., November (Thayer); eastern Texas (Woldert); Cuba (Lazear).

CULEX IMPIGER Walk.

Habitat: White Mountains, N. H.; Beverly, Mass., May 24, June 2 (Nat. Mus.); Ithaca, N. Y., July 9 and 17, August 28; Wilmoth, N. Y., June 10 (Comstock); Saskatchewan River, British America (Nat. Mus.); Minnesota (Lugger); Loudoun County, Va., August 26 (Pratt); Tyrone, Ky., July 14 (Garman); Georgia (Nat. Mus.); Mesilla, N. Mex. (Cockerell); Isle of Pines, West Indies (Scudder); Portland, Jamaica (Johnson); District of Columbia, September 12 (Barber); Alexandria, Va. (Pratt); Ogdensburg, N. Y., June 3 (Howard); Middletown, Conn., June (Davis); Ottawa, Canada, May 31 (Howard); Chats Rapids, Quebec, May 24 (Fletcher); Buckeye, Wash. (Nat. Mus.); Stikine River, British Columbia (Wickham).

CULEX PERTURBANS Walk.

Habitat: Lakeland, Md., August 8 (Pratt); Virginia, August 17 (Pergande); Tick Island, Fla., May 12 (Johnson); Texas (Nat. Mus.); Bayamon, Porto Rico, January (Busck); District of Columbia, September 1-5 (Barber); St. Elmo, Va., June, July (Pratt); Cuba (Lazear).

CULEX POSTICATUS Wied.

Habitat: Montgomery County, Pa., July 17 (Johnson); Texas (Nat. Mus.); Loudoun County, Va., August (Pratt); Roanoke, Va., October (Thayer); District of Columbia, June 10 (Barber).

CULEX PUNGENS Wied.

Habitat: White Mountains, N. H.; Beverly, Mass., September 5; Cambridge, Mass., September 16 to November 5; Boston, Mass.; Baltimore, Md., November 5 (Nat. Mus.), November 26 (Lugger); Charlton Heights, Md., December 1 (Pratt); District of Columbia, January 30, March 5, May 6 and 15, June 28, July 11, August, October 10, 15, 25, and 31, November 4, 8, 13, 16, and 23,

December 23 (Pergande); Ithaca, N. Y., May 29, July 17, August 28 (Comstock); Illinois (Nason); Minnesota (Lugger); Lincoln, Nebr., September 20 (Bruner); Lexington, Ky., November 10 (Garman); New Orleans, La., December 17 (Howard); San Antonio, Tex., May 5 (Marlatt); Georgia, August (Coquillett); Portland, Jamaica, (Johnson); Mexico City (Barrett); District of Columbia, August 22, 28, September 1 (Barber); Jackson, Va., October (Thayer); Woodstock, Va., June (Pratt); Newport News, Va., October (Thayer); Stillwater, Okla., June (Bogue); Philadelphia, Pa., (Woldert); New Orleans, La., June (Veazie); eastern Texas (Woldert); Summit, N. J., May (La Rue Holmes); Middletown, Conn., June (Davis); Cuba (Lazear).

CULEX SIGNIFER Coq.

Habitat: District of Columbia, June (Coquillett), May, August (Barber); St. Elmo, Va., June 4 (Pratt).

CULEX STIMULANS Walk.

Habitat: White Mountains, N. H.; Beverly, Mass., June 2, July 9; Cambridge, Mass., May; Jamaica Plain, Mass., August 25 (Nat. Mus.); Baltimore, Md. (Lugger); Illinois, August 1, September 15, October 5 (Nason); Agricultural College, Mich. (Gillette); Saskatchewan River, British America (Nat. Mus.); Lincoln, Nebr. (Bruner); Colorado (Nat. Mus.); Ithaca, N. Y., June 13, 18, 29, July 14, August 28; Wilmoth, N. Y., June 10 (Comstock); Georgia (Nat. Mus.); Bladensburg, Md., May 27 (Barber); St. Elmo, Va., June 5 (Pratt); District of Columbia, September (Barber), June 10 (Miss L. Sullivan); Ottawa, Canada, June 1 (Howard); Ogdensburg, N. Y., June 3 (Howard); Rochester, N. Y. June (Ewers); Summit, N. J., May (La Rue Holmes); Middletown, Conn., June (Davis); Mesilla, N. Mex., October 26 (Cockerell); Tacna, Ariz., April 13 (Hubbard); Juarez, Mexico, May 12 (Cockerell); Summit, N. J. (Holmes).

CULEX TENIATUS Wied.

Habitat: New Orleans, July (Veazie); Cuba (Lazear).

CULEX TENIORHYNCHUS Wied.

(Not the *Culex teniorhynchus* Wied. of Arribalzaga.)

Habitat: Maine, August; Beverly, Mass., June, September 15 (Nat. Mus.); Avalon, Anglesea, and Atlantic City, N. J., July 10 to 29 (Johnson); Far Rockaway, Long Island, N. Y., August 30 (Howard); District of Columbia (Pergande); Georgia (Nat. Mus.); St. Augustine and Charlotte Harbor, Fla., July; Portland, Jamaica (Johnson); Chesapeake Beach, Md. (Barber); Baltimore, Md. (Thayer); Plymouth, N. C. (Thayer); Galapagos Islands, February 1-4 (Snodgrass).

CULEX TARSALIS Coq.

Habitat: Argus Mountains, Cal., April; Folsom, Cal., July 3 (Nat. Mus.).

CULEX TRISERIATUS Say.

Habitat: White Mountains, N. H. (Nat. Mus.); Delaware County, Pa., June 12 (Johnson); Washington, D. C., May 5 and June 10; Loudoun County, Va. (Pratt); Near Baltimore, Md. (Thayer); Roanoke, Va., October (Thayer); Middletown, Conn., June (Davis); New Jersey (Woldert).

THE BIOLOGY OF ANOPHELES, WITH GENERAL REMARKS.

So far as the writer can ascertain, no detailed illustrated account of the early stages of any species of Anopheles had been published before his paper in the Scientific American, above referred to.¹ He conceived it to be nearly as important that the malarial-bearing mosquitoes should be readily recognized in their early stages as in their adult condition. He was very fortunate in April of the present year in being

¹ See appendix.

able to secure a large number of gravid females of *Anopheles quadrimaculatus* Say through the abundance of this species near the home of one of his assistants, Mr. Pratt, in Virginia, a few miles from Washington. Mr. Pratt was enthusiastic and assiduous in collecting living adults, and these were kept in confinement and their offspring reared in large water jars during April and May, 1900. It may be mentioned here that this species is without doubt identical with the European *Anopheles maculipennis* Meigen, a fact which Mr. Coquillett has always strongly suspected, although he had no European material with which to compare our American specimens. Dr. W. S. Thayer saw *A. maculipennis* in Grassi's laboratory in Italy, and on his return to this coun-



FIG. 6.—*Anopheles quadrimaculatus*: Adult; male at left, female at right—enlarged (original).

try told the writer that he thought the two forms identical. The question has now been definitely settled by Mr. F. V. Theobald, of England, who is monographing the mosquitoes of the world for the British Museum, and who writes us under date of May 28, 1900, that he has studied a large series of *A. quadrimaculatus* received from Canada and that "they exactly tally with *A. maculipennis*."

LIFE HISTORY OF ANOPHELES QUADRIMACULATUS.

THE ADULT.—The accompanying illustrations (figs. 6, 7, 8) will show very well the general appearance of the adult insect. It is a rather

large mosquito and is very blood-thirsty. It is attracted to the house in numbers. The differences between the males and females are well brought out in the illustrations, and the striking feathery antennae and palpi of the male render it very conspicuous. The wing markings and the color of the palpi differentiate this species from our other species of *Anopheles*, and the long palpi of the female at once distinguish it from all species of *Culex*.

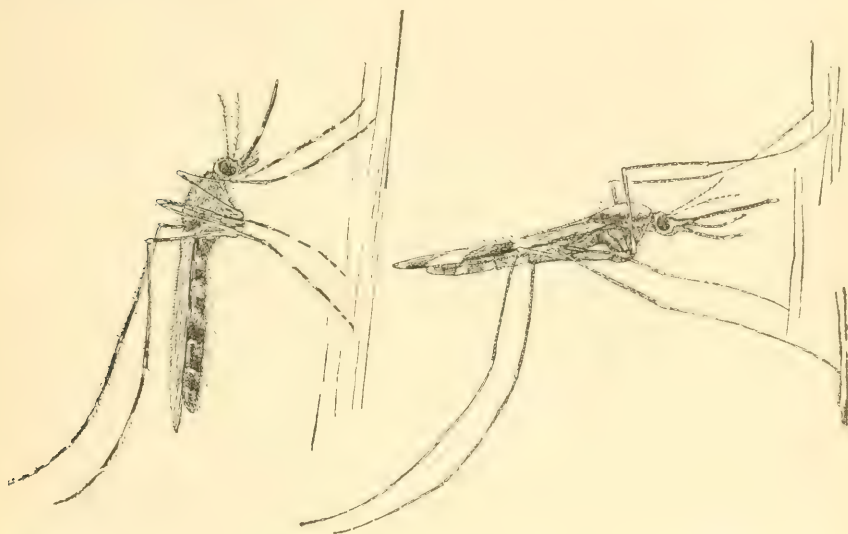


FIG. 7.—Resting positions of *Culex* (at left) and *Anopheles* (at right), enlarged (redrawn from a rough sketch published in the *British Medical Journal*).

Resting position.—Owing to the publication of a field sketch made at Sierra Leone by a member of the Ross expedition, and which is here reproduced, the writer has been much interested in watching the resting positions of the adult insects. He finds that when resting upon a horizontal surface—such as the ceiling of a room or the covering of the breeding jars—the insect clings with its four anterior legs in a nearly perpendicular position, its beak thrust forward toward the surface to which it clings. The hind legs are frequently in motion, but as a rule hang downward with more or less of a bend at the knee joint (femero-tibial articulation). When resting upon a perpendicular surface, however—such as the side wall of a room or the side of a breeding jar—the body is held only at a comparatively slight angle from the surface. Sometimes it is nearly parallel with the surface. At other times it assumes an angle of 10° to 20° (occasionally even as great an angle as 30° to 40°), the proboscis being held nearly in a line with the body. Here again the insect supports itself by the four anterior legs, the hind legs dangling down with more or less of a bend at the

knee. This position is common to both males and females, and is illustrated at fig. 8. When the body is held parallel it will generally be found that one of the middle or hind legs has been broken off. They are very delicate and readily break.

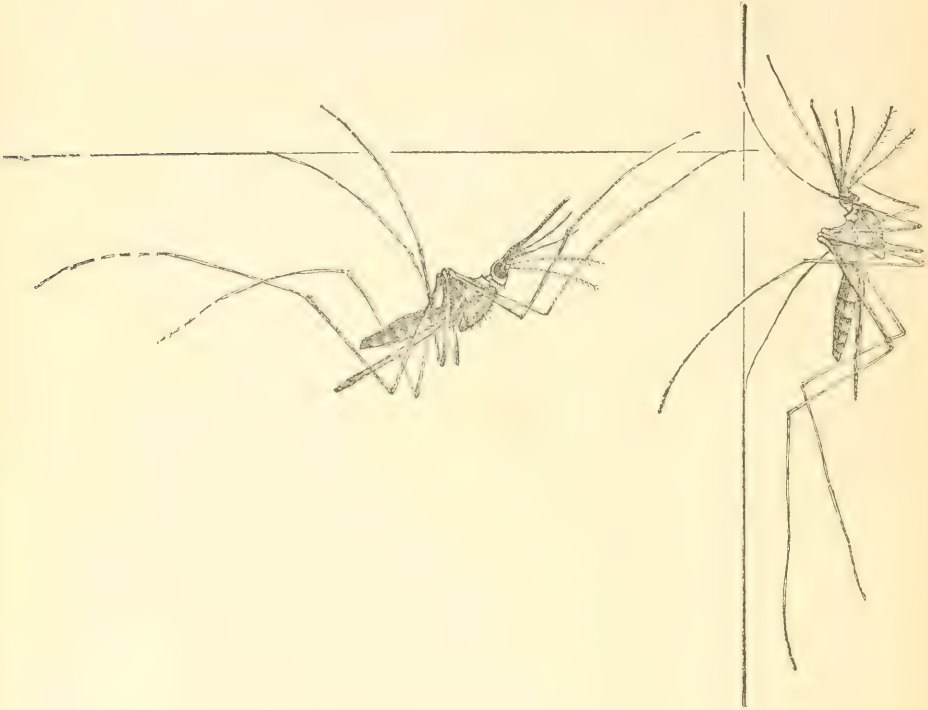


FIG. 8.—Actual resting positions of *A. quadrimaculatus* on a horizontal ceiling and on a side wall; drawn from life—enlarged (original).

The writer has taken the liberty of having fig. 9 engraved from a drawing sent him by Mr. C. O. Waterhouse of the British Museum. Mr. Waterhouse made the drawing himself and wrote: "Whatever

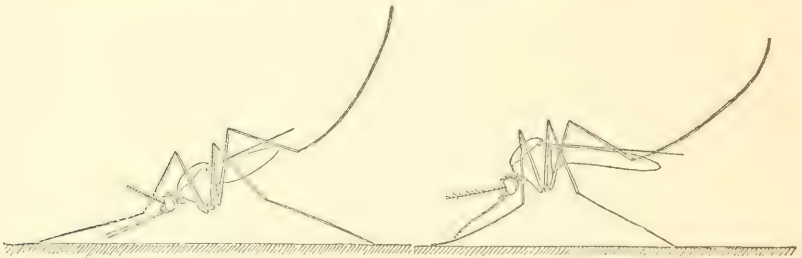


FIG. 9.—*Anopheles* at left, *Culex* at right—enlarged (drawn by C. O. Waterhouse).

may be the attitude of *Anopheles*, it is all in one line. *Culex* is angular, humpbacked."

Note of female.—The peculiar hum of the mosquito is well-known. There is a distinct difference between the hum of *Anopheles quadrima-*

culatus and that of the common species of *Culex* in that the former is noticeably lower in tone. The note of *Culex* as it approaches the ear



FIG. 10.—*Anopheles quadrimaculatus*: Group of 44 eggs deposited by a single female as they appear resting naturally on the surface of the water—enlarged (original).

is high in pitch; that of *Anopheles* is certainly several tones lower and of not so clear a character. In quality it is something between the buzzing of a house fly and the note of *Culex*. Mr. Pratt states that he can at once distinguish the two genera in this way as he is sitting reading in the house, and the writer feels quite sure after listening to them in breeding jars that the statement is correct.

These observations have been made with an abundance of material, nearly 100 adults having been under observation.

THE EGGS.—The well-known and often-mentioned boat-shaped masses of eggs of *Culex* are not even remotely resembled by the *Anopheles* ovipositions, and the individual eggs are equally dissimilar. In the accompanying illustration (fig. 10) the egg mass of *Anopheles* is illustrated for comparison with fig. 1. In *Culex* from 200 to 400 eggs are laid in a mass ordinarily shaped like a pointed ellipse, convex below and concave above, all the eggs perpendicular, and stuck

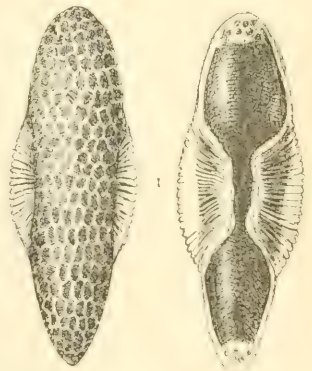


FIG. 11.—*Anopheles quadrimaculatus*: Egg from below at left, from above at right—greatly enlarged (original).

closely together at the sides by some gummy secretion, and arranged in rows. The mass with *Anopheles*, however, is laid loosely upon the surface of the water, each egg lying upon its side instead of being placed upon its end as in the egg mass of *Culex*. They are not attached together except that they naturally float close to each other and there are from 40 to 100 eggs in each lot. In *Culex pungens* the individual egg is 0.7 mm. long and 0.16 mm. in diameter at the base. It is slender, broader, and blunt at the bottom, slenderer and more pointed at the tip. The tip is always dark grayish brown in color, while the rest is dirty white. The egg of *Anopheles* when seen from above is of a rather regular elliptical outline, the two ends having practically the same shape; seen from the side, it is strongly convex below and nearly plane above; seen from below, it is dark in color and when examined with a high power is seen to be covered with a reticulate hexagonal sculpturing. At the sides, in the middle, there appears a clasping membrane with many strong transverse wrinkles. Seen from above, the egg is black except for a clasping membrane which nearly

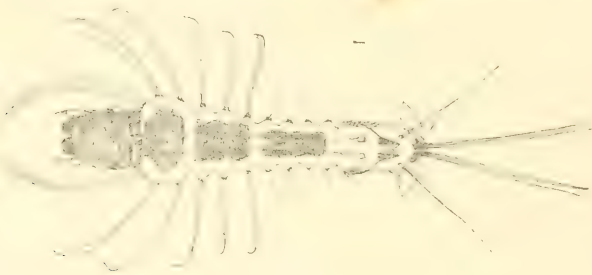


FIG. 12.—*Anopheles quadrimaculatus*: Newly hatched larva—greatly enlarged (original).

meets on the middle line in the middle third of the body, but retires to the extreme sides for the anterior and posterior thirds. At each end the color is lighter, with a group of from 5 to 7 minute dark circular spots. It is 0.57 mm. long. Eggs laid April 26 hatched April 30. Others laid May 13 and 14 hatched May 16 and 17.

THE LARVA.—The larva is quite as unlike that of *Culex pungens* as is the egg. It differs in structure, in its food habits, and in its customary position so markedly that it can at once be distinguished with the utmost ease. The larva of *Culex*, it will be remembered, comes to the surface of the water to breathe, thrusting its breathing tube through the surface layer and holding its body at an angle of about 45 degrees with the surface of the water. While in this position its mouth parts are in motion and it is taking into its alimentary canal such minute particles as may be in the water at that depth, but these are naturally few in number and the larva descends at frequent intervals toward the bottom to feed. The want of oxygen, however, causes it to wriggle up again to the surface at very frequent intervals. Its

specific gravity seems greater than that of water, so that it reaches the surface only by an effort, and the writer has already pointed out in the case of *C. pungens* that when the larva becomes enfeebled and is not strong enough to wriggle up to the surface it drowns. Feeding as it does at the bottom upon the heavier particles which sink, its specific gravity is explained. The larva of *Anopheles quadrimaculatus*, however, habitually remains at the surface of the water. Its breathing tube is very much shorter than that of *Culex* and its body is held not at an angle at the surface, but practically parallel with the surface and immediately below the surface film, so that portions of its head, as well as its breathing tube, are practically out of the water. Its head rotates upon its neck in a most extraordinary way, so that the larva

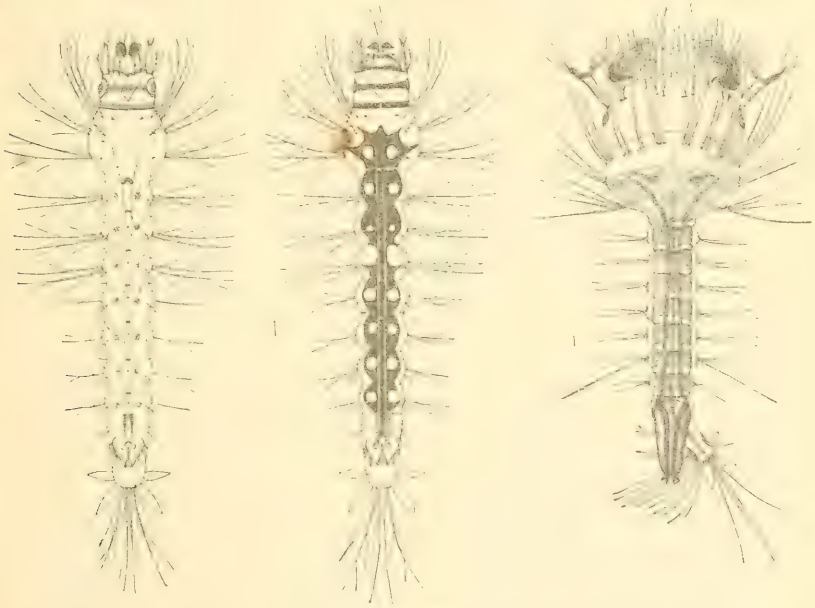


FIG. 13.—*Anopheles quadrimaculatus* and *Culex pungens*: Half-grown larva at left and in center, in comparison with half-grown larva of *Culex pungens* at right (figure at left has been cleared)—greatly enlarged (original).

can turn it completely around with the utmost ease and feeds habitually with the under side of the head toward the surface of the water, whereas the upper side of the body is toward the surface. In this customary resting position the mouth parts are working violently, the long fringes of the mouth parts causing a constant current toward the mouth of particles floating on the surface of the water in the neighborhood, which thus gradually converge to this miniature whirlpool and enter the alimentary canal. The spores of algae, bits of dust, minute sticks, bits of cast larval skins, everything in fact which floats, follow this course, and, watching the larva under the microscope, they can plainly be seen to pass through the head into the thorax until they

are obscured by the dark color of the insect's back. Occasionally too large a fragment to be swallowed with ease clogs the mouth. Sometimes it enters the mouth and sticks. In such cases the head of the larva revolves with lightning-like rapidity and the fragment is nearly always disgorged, although sometimes it is swallowed with an evident effort. Since the *Anopheles* larva feeds only upon these light floating particles, its specific gravity is nearly that of the water itself and it supports this horizontal position just beneath the surface film with comparative ease, and in fact without effort, the tension of the surface

film itself being hardly needed to hold it. It requires an effort in fact for the *Anopheles* larva to descend (which it apparently never does up to the period of the final larval stage, except when alarmed), while it requires an effort for the *Culex* larva to ascend.

Structurally the differences between the half-grown larvæ of *Culex* and *Anopheles* are well shown at figs. 13, 14, and 15. The great size of the head of *Culex*, as contrasted with the small head of *Anopheles* is a most striking difference. The very long respiratory

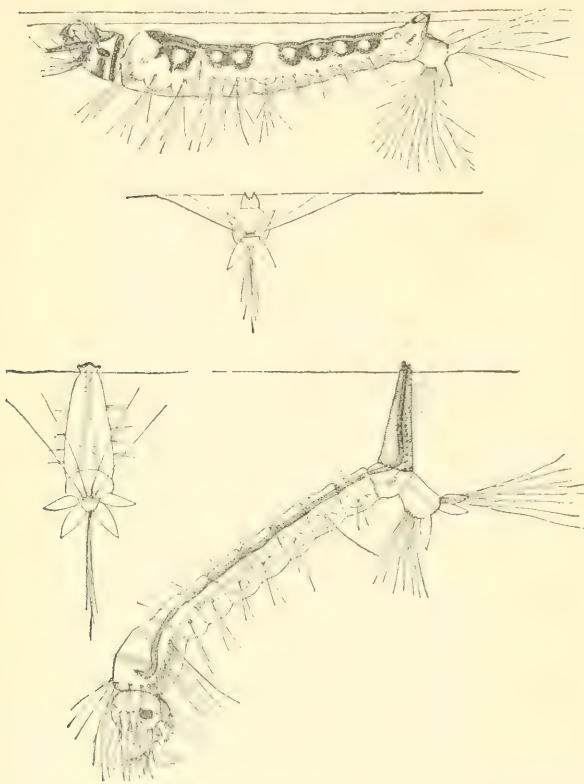


FIG. 14.—Figure at top, half grown larva of *Anopheles* in feeding position, just beneath surface film. Figure at bottom, half grown larva of *Culex* in breathing position—greatly enlarged (original).

siphon (as Miall calls it) of *Culex* contrasts markedly with the short one of *Anopheles*. The arrangement of the hairs is entirely different, the branching of the hairs of *Anopheles*, as contrasted with the simple hairs of *Culex* and the little paired star-shaped (apparently branchial) tufts on the dorsum of *Anopheles* are entirely absent with *Culex*. The flaps at the tail end of the body are similar in number, but are held in a somewhat different position.

The larvæ first studied—those which hatched from the eggs on April 30—grew very slowly for a number of days. This was partly owing to cool weather in the early part of May, and partly, I believe, to the absence of proper food. They were reared in glass jars of water, with sand at the bottom and a willow twig rooting in the sand. As above noted, they swallowed every small particle floating on the surface of the water, and the dark coloration shown in fig. 14 was largely due to the fact that most of these food particles were dark colored. About the 10th of May, the larvæ having passed through two molts, a small quantity of the green algæ growing on the lily ponds on the Department grounds was placed in the jar.¹ The larvæ commence to thrive much better, grew rapidly, and the general color of the body changed to green. The description of the habits given above held well until after the last molt preceding the change to pupæ. In this final larval stage, as shown in fig. 15, the diameter of the thorax became much greater in comparison with the rest of the body. The larva was less marked, more inconspicuous, and altered its feeding habits to some extent. After

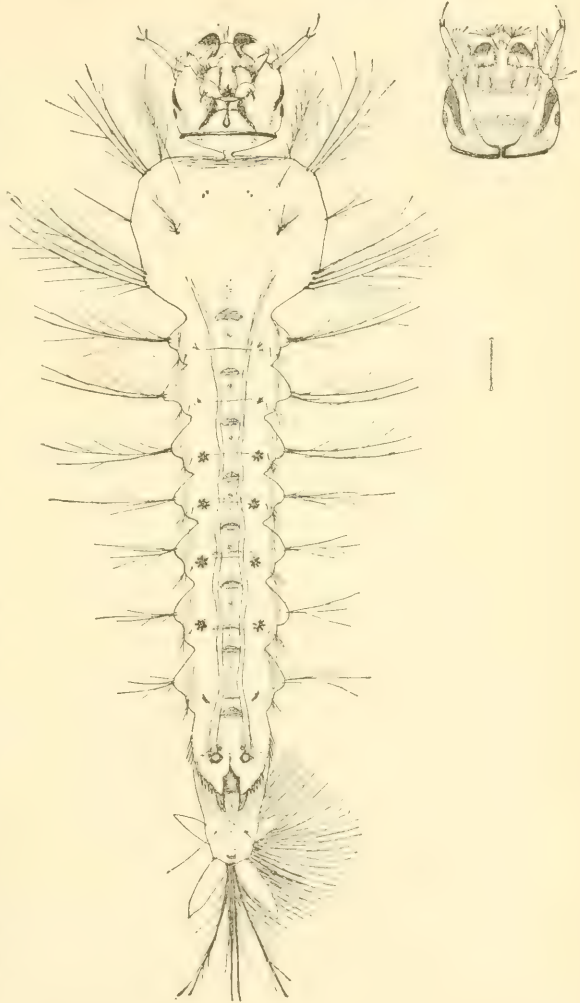


FIG. 15.—*Anopheles quadrimaculatus*: Full grown larva in feeding position, seen from above (head reversed, in feeding position); dorsal side of head above at right—greatly enlarged (original).

¹These algæ were studied by Mr. A. F. Woods, of the Division of Vegetable Physiology and Pathology, who informed me that the larger part belong to a species of the genus *Edogonium*, but that there was also quite a large amount of a species of *Cladophora*, with some *Spirogyra*. There was also some of the blue green *Oscillaria*.

remaining at the surface of the water, feeding, as before, upon floating particles for some time, it would wriggle violently and descend to the bottom, where it would remain frequently as long as two minutes before reascending to the top. Its appetite was evidently so great that it was not satisfied with the floating particles, and when it descended to the bottom it mouthed the particles of sand, evidently swallowing the slime on the little stones and frequently even picking up quite a large sand pebble and then dropping it again. In this stage the individual which grew most rapidly remained only four days, and transformed to pupa on the morning of the 17th, after a larval existence of sixteen days. The accompanying figures of the larvæ have been drawn with such care that detailed description will be unnecessary. They were drawn from life under the compound microscope. Some of the structures are puzzling, notably the organs occurring on the dorsum of the abdominal segments, shown most plainly in fig. 15, and which look as though they might be spiracles until they are examined under a high power in the cast skin. The writer does not care to risk an expression of opinion as to their function, although possibly it is known, and they possibly occur in other aquatic dipterous larvæ. In the early stages of the larvæ they resemble minute branchial tufts, but no tracheal connection has been found.

THE PUPA.—The accompanying figure (fig. 16) well represents the

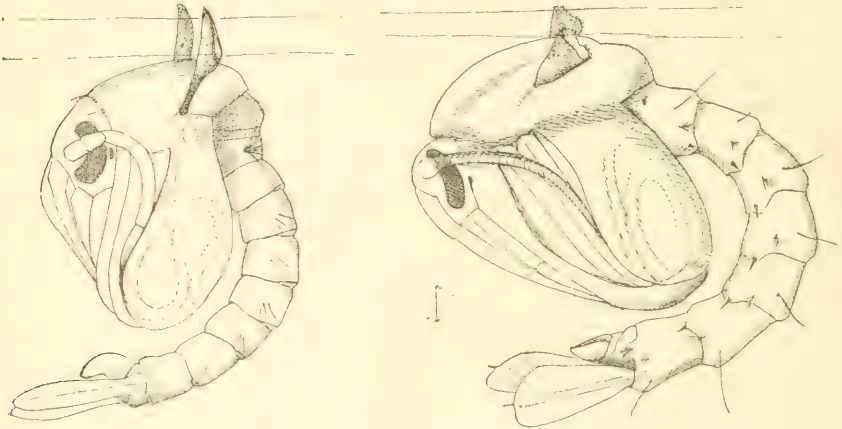


FIG. 16.—Pupa of *Culex pungens* at left; pupa of *Anopheles quadrimaculatus* at right—greatly enlarged (original).

differences between the pupa of *Culex* and that of *Anopheles*. In this stage the insects of the two genera are not so markedly different as in the larval stage. Structural differences need not be described, as they are sufficiently shown in the illustration. The eye will at once be caught by the difference in position, the pupa of *Culex* resting in a more perpendicular attitude than that of *Anopheles*, and the marked difference in shape between the respiratory siphons, which issue from the thorax instead of from the anal end of the abdomen, will at once

be noticed. The pupa of *Anopheles* is quite as active, when disturbed, as is that of *Culex*. If one touches the near-by surface of the water with the finger the pupa at once wriggles violently away, returning shortly to the surface for air.

The duration of the pupal stage in *Anopheles* varies according to the weather. Five days was the minimum observed during June, although several specimens remained in this stage for ten days. The adults issue as do those of *Culex*.

The entire life round, therefore, of *Anopheles quadrimaculatus* in the generation studied by the writer is as follows: Egg stage, three days; larval stage, sixteen days; pupal stage, five days; making a total period in the early stages of twenty-four days. It should be stated, however, that during the early larval existence toward the end of May there occurred nearly a week of cool weather, so that it is certain that in the hot season in July and August the growth and transformations will be more rapid. It will be remembered that the writer traced *Culex pungens* through an entire generation in the latter part of June, 1895, in ten days.

NATURAL BREEDING PLACES OF ANOPHELES.

Having accomplished the preliminary work of studying different stages of growth of *Anopheles* by breeding from captured females, we were enabled to become familiar with the larvæ and pupæ so as to recognize them readily and it was then not difficult to find the natural breeding places. The first breeding place discovered was in Maryland, and the larvæ found there were those of what is probably *A. punctipennis*. They closely resemble the corresponding stage of *A. quadrimaculatus* except in the maculation of the head. A figure of the head of this form is shown here (fig. 17) in order that it may be compared with the corresponding figure of *A. quadrimaculatus* shown in fig. 15. This first breeding place of *Anopheles* was a small permanent stream running through the woods which had here and there broadened out into little shallows, and in these shallows the *Anopheles* larvæ were found resting at the surface of the water, and occasionally darting from one spot to another. All of these little pools were abundantly supplied with algæ, and from specimens brought in Mr. A. F. Woods has found that they belong to the genus *Mougeotia*. There were also many Diatoms present. The next natural breeding place found was in pools about a disused spring in Virginia. At the sides of the spring were several more or less permanent pools of considerable depth (8 to 10 inches). Here the larvæ of *A. quadrimaculatus* were found. Algæ also occurred here and Mr. Woods has determined them as belonging to the same genus *Mougeotia*. The



FIG. 17.—*Anopheles punctipennis*: Head of full-grown larva from above—enlarged (original).

temperature of this water was 18° C. The third locality was an old canal bed so nearly dried out after a season of drought that the water lay in rather small puddles. In this case the water was very foul and algae of the genus *Lyngbya* were present. The temperature of this water was 25° C., and the conditions were those of extreme stagnation. The first locality was discovered by the writer in company with Mr. Pratt and the second and third were found by Mr. Pratt. Later, the writer in company with Mr. Busek and Hospital Steward Smith, found empty pupa skins of *A. quadrimaculatus* in a dried up surface pool at the Washington Barracks, at a time when malaria was very prevalent among the troops. I am informed by Dr. Thayer, of Baltimore, that Dr. Lazear found *A. punctipennis* breeding in a stone quarry near Baltimore, in the summer of 1899. Ross found in India that while the species of *Culex* generally bred in vessels of water around the houses, the species of the genus *Anopheles* bred in small pools of water on the ground. This point was made the subject of a special investigation by the expedition of the Liverpool School of Tropical Medicine to Sierra Leone. While *Culex* larvæ were to be seen in almost every vessel of water or empty gourd or flowerpot in which a little rain water had collected, in only one case were *Anopheles* larvæ found in such receptacles. On the other hand, they occurred in about 100 small puddles scattered throughout the city of Freetown—puddles mostly of a fairly permanent description, kept filled by the rain, and not liable to washing out during heavy showers. It was noticed also that the larvæ seemed chiefly to feed on green water weed.

In the interesting and important paper by Dr. J. W. W. Stephens and Mr. S. R. Christophers entitled "The distribution of *Anopheles* in Sierra Leone," published in the report of the malarial committee of the Royal Society, July 6, 1900, it is stated that at Freetown not only do the larvæ of *Anopheles* exist in the small pools in the rocks, but also in the pools by the sides of streams and in certain small drains, and that in the dry season, in the absence of the rock pools, *Anopheles* breeds freely in streams and drains; also, in the dry season, the adults exist in most parts of the town in dwellings, especially in overcrowded native huts and native quarters, ready to lay their eggs when pools appear. It is interesting to note, from this latter observation, that the authors of the paper recommend the destruction of dirty huts and the prevention of excessive overcrowding. Outside of the city, in the "bush," *Anopheles* larvæ were present throughout the whole district. In the mountain streams, wherever there were suitable pools, multitudes of larvæ existed. In tracing the mountain streams, occasionally for a half mile or so, they found no larvæ, but then a rock pool occurred, and there they were again found in numbers. At Songo and Mabang they were able to detect *Anopheles* larvæ in the swamps. They were not present in the main swamp water on account

of the innumerable small fish, but were occasionally observed in small, isolated pools on the mud, and were still more common in small pools at the edges of swamps. It is a noteworthy fact that they did not occur in swamp pools in such numbers as in the streams and rock pools among the hills of Sierra Leone. "These rock pools would appear to be the most suitable conditions for the breeding of *Anopheles*."

The avidity with which *Anopheles* larvæ under observation in Washington fed upon algæ spores of the genera previously mentioned, and the character of the breeding pools found here, indicate that without doubt similar conditions will prevail generally in this country, and *Anopheles* will always be found to breed most abundantly in fairly permanent stagnant pools of water uninhabited by fish, but more or less covered with green scum.

OTHER SPECIES OF ANOPHELES.

As appears from the synoptic table on previous pages, we have in the United States, so far as ascertained, three recognized species of

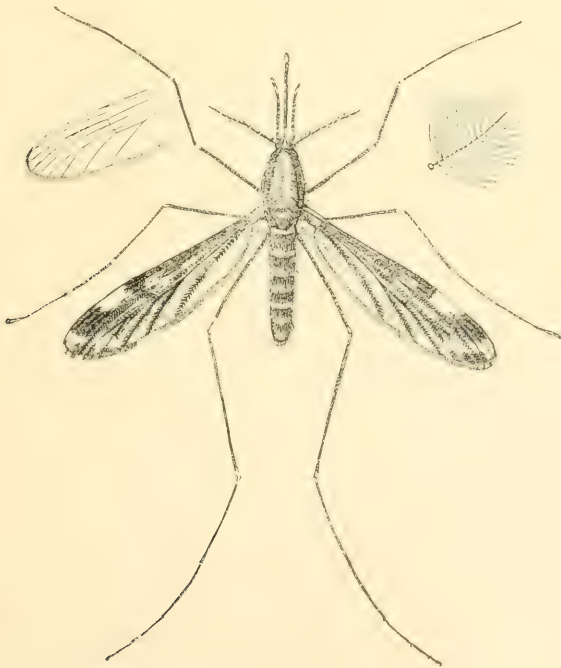


FIG. 18.—*Anopheles punctipennis*: Female, with male antenna at right, and wing tip showing venation at left—enlarged (original).

this genus. *A. quadrimaculatus* has just been figured in all its stages, and the accompanying illustration (fig. 18) shows very well the beautiful

species known as *A. punctipennis* Say. *A. crucians* (fig. 19) seems to be rarer than the other two and has been taken only in a few instances.

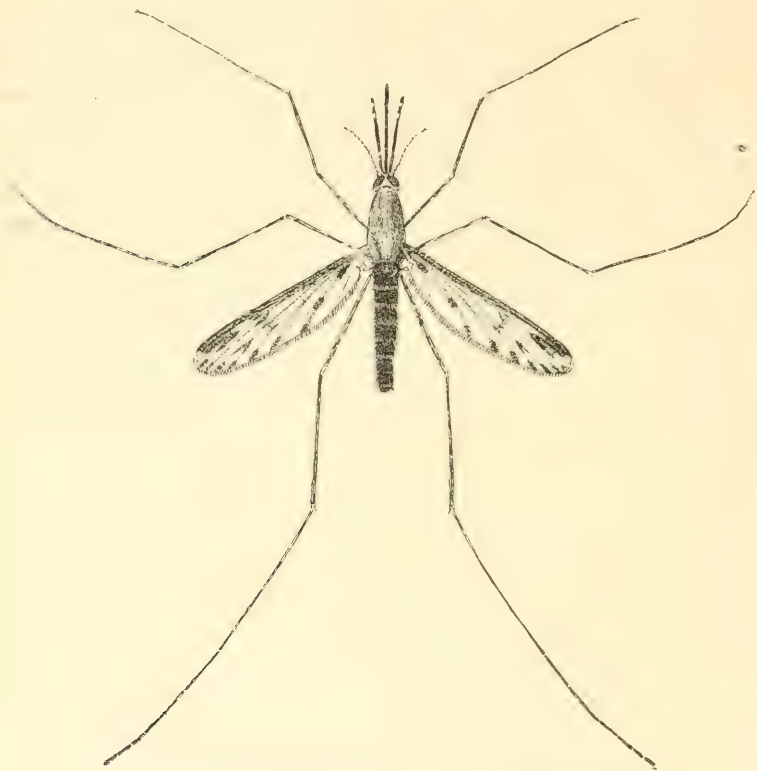


FIG. 19.—*Anopheles crucians*: Female—enlarged (original).

DISTRIBUTION OF THE SPECIES OF ANOPHELES IN THE UNITED STATES.

ANOPHELES CRUCIANS Wied.

Habitat: District of Columbia, April 27 (Pergande); Georgia (Nat. Mus.); New Orleans, La., June 28 (Veazie), November (Thayer); Richmond, Va. (Slosson).

ANOPHELES PUNCTIPENNIS Say.

(Considered by Wiedemann to be the same species as his *Anopheles crucians*, but the two are certainly distinct.)

Habitat: Castleton, Vt., February 1 (temperature 6° F.); Beverly, Mass., September 19, October 2; Cambridge, Mass., June 16, September 30, October 20 (Nat. Mus.); Charlton Heights, Md., March 31, November 17 (Pratt); District of Columbia, June 6 and 7, October 15, 25, and 31 (Pergande); Philadelphia, Pa., October 12 (Johnson); Ithaca, N. Y., April 17, August 28 (Comstock); Illinois, October 16 (Nason); Texas (Nat. Mus.); Mesilla, N. Mex. (Cockerell); Portland, Jamaica (Johnson); Middletown, Conn. (Davis); Summit, N. J., April 26 (Howard); Roanoke, Va., October (Thayer); St. Elmo, Va., May, June (Pratt); Brazos River, Tex. (Woldert); Baltimore (Thayer and Lazear); Walbrook, Md. (Thayer and Lazear); Onaga, Kans. (Crevecoeur).

ANOPHELES QUADRIMACULATUS Say.

Habitat: Berlin Falls, N. H., August (Nat. Mus.); Ithaca, N. Y., January, July 31, November 28 (Comstock); Lakeland, Md., August 8; Charlton Heights, Md.,

November 24 (Pratt); District of Columbia, July, October 15, November 2 and 14 (Pergande); Illinois, September 10, October 10 (Nason); St. Anthony Park, Minn., December 11 (Lugger); Tick Island, Fla., May 12 (Johnson); Texas (Nat. Mus.); Oneco, Fla., May 26 (Gossard); Roanoke, Va., October (Thayer); Newport News, Va., October (Thayer); St. Elmo, Va., April, May, June, July (Pratt); New Orleans (Thayer); Sparrows Point, Md., and vicinity (Thayer and Lazear); Middletown, Conn. (Davis).

THE GENUS PSOROPHORA.

But one species, *P. ciliata*, of the genus *Psorophora* is known in the United States. This is well illustrated in the accompanying figure (fig. 20). Although this insect, as indicated in the synoptic

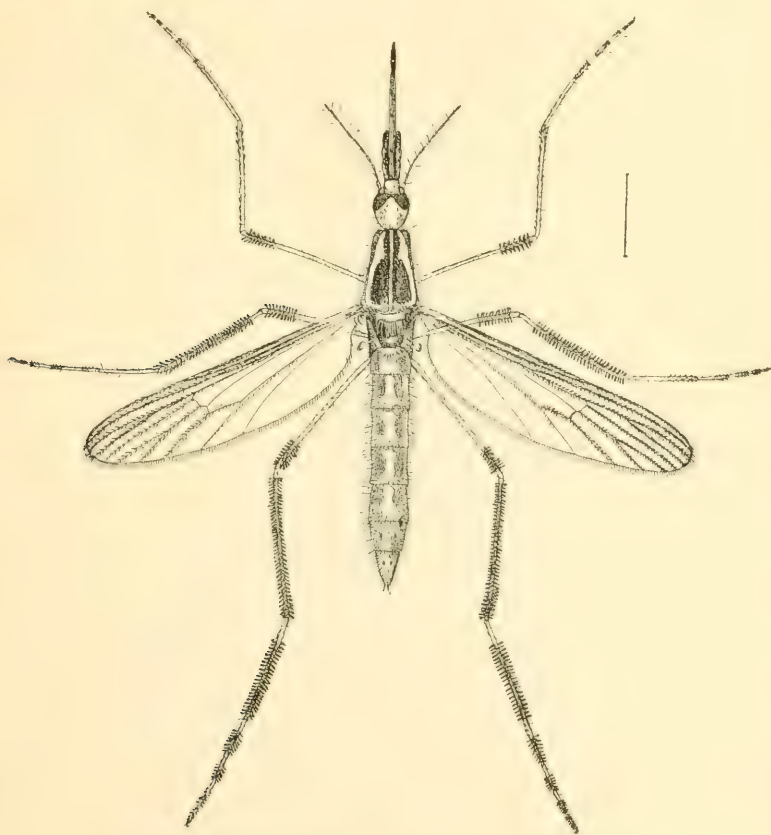


FIG. 20.—*Psorophora ciliata*: Female—enlarged (original).

tabies, is really yellowish in color, yet the general effect when one glances at it, or sees it flying, is that it is very dark, almost black. The wings are not really spotted or infuscated, but the very numerous dark scales on the main veins make the wings appear dark. They are also when seen in certain lights prismatic in color effect. The palpi of the female are nearly half as long as the beak, and the beak itself

is very stout. The most striking feature of this insect, however, is the curious series of erect close-set hairs or scales on the legs, which distinguishes it at once from other mosquitoes. This mosquito is widespread in the United States, and we have specimens from Dorchester, Mass. (Nat. Mus.); Washington, D. C. (Chittenden); Westfield, N. J., July 2 (Johnson); Illinois (Nason); Brooklyn Bridge, Ky., June 23 (Garman); Lincoln, Nebr., July and August (Bruner); Los Angeles, Cal. (Coquillett); San Diego, Tex., May 15 (Schwarz); Florida, July (Nat. Mus.); Hastings, Fla., July (Dept. Agric.); New Orleans, August, (Veazie). A rather large series was captured in June of the

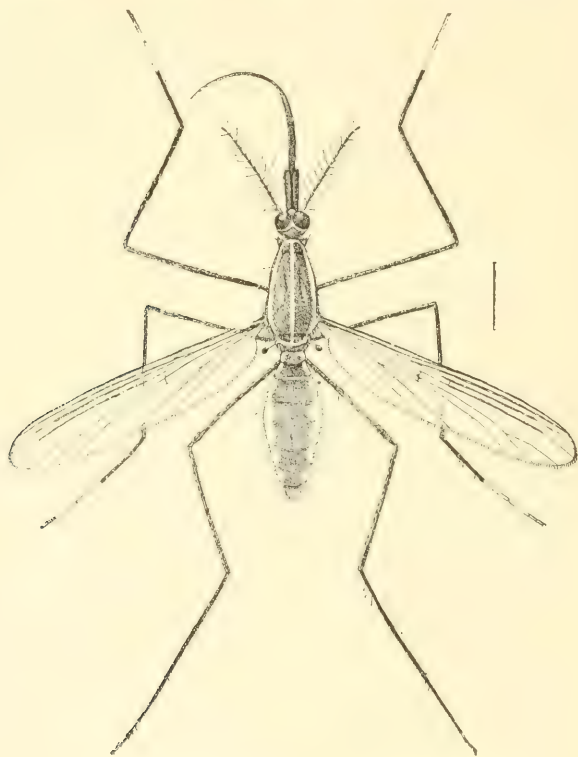


FIG. 21.—*Megarhinus rutilus*: Female—enlarged (original),

present year at St. Elmo, Va., by Mr. Pratt. The writer felt certain that he would be able to follow out the life history of this species from the living material captured by Mr. Pratt. Females were placed alive in breeding jars under conditions which had repeatedly been successful with *Culex* and *Anopheles*, but no eggs were obtained. The breeding habits, therefore, may be different from those of the other two genera, and the biology of this form is an interesting and important point for future investigation. As elsewhere stated, the possible relations between *Psorophora* and the *Hæmatamœbæ* deserve early investigation.

THE GENUS MEGARHINUS.

This is the other genus (fig. 21), the species of which are more or less abundant in the South, which should be investigated by Southern observers in regard to its possible connection with malaria. As indicated in the synoptic table, the mosquitoes of this genus are readily distinguished by the curved beak, which is also well shown in the drawing. They are especially distinguished also by their metallic greenish or bluish coloration. Nothing is known of the life history of the mosquitoes of this genus, and the species known to occur in this country are distributed as follows, so far as our records go:

MEGARHINUS FEROX Wied.

Habitat: District of Colombia, August 22 (Pergande); (Georgia according to Walker's list).

MEGARHINUS HÆMORRHOIDALIS Fabr.

Habitat: (Cayenne and Cuba according to Osten Sacken's catalogue).

MEGARHINUS PORTORICENSIS Roeder.

Habitat: Benoit, Miss., July 18 (Hine).

MEGARHINUS RUTILUS Coq.

Habitat: North Carolina; Georgiana, Fla. (Nat. Mus.).

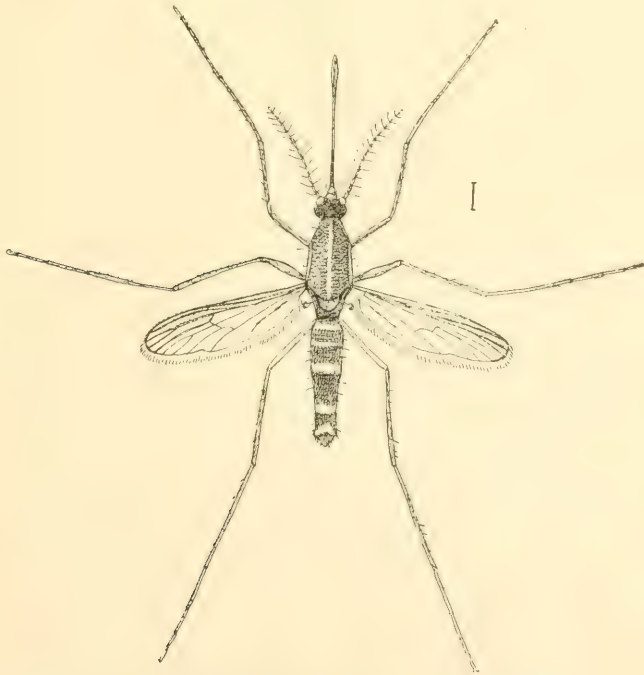


FIG. 22.—*Aedes sapphirinus*: Female—enlarged (original).

THE GENUS AËDES.

The mosquitoes of this genus (fig. 22) are minute forms, insignificant in color, and the only one of which we possess specimens, viz., *A. sapphirinus*, is shown in the accompanying figure. We have received it

only from Ithaca, N. Y., through the kindness of Prof. J. H. Comstock. Another species, *A. fuscus*, is said by Osten Sacken to occur at Cambridge, Mass.

THE NATURAL ENEMIES OF MOSQUITOES.

The late Dr. Robert H. Lamborn, of New York and Philadelphia, while engaged a number of years ago in building the Lake Superior and Mississippi Railroad, fell in with a great many mosquitoes. He often, "with a sentiment of gratitude," as he expressed it, looked through his mosquito veil at the dragon flies which collected in the open spaces among the pine trees. "They darted from side to side, like swallows in a meadow, but with amazing rapidity, and at every turn a mosquito 'ceased from troubling.' " This gave Dr. Lamborn the idea that perhaps dragon flies might be domesticated and utilized to destroy mosquitoes along the New Jersey coast and elsewhere; and so he offered prizes for the three best essays regarding methods of destroying the mosquito and the house fly, especially designating the dragon fly for careful investigation. The successful essays—by Mrs. C. B. Aaron, Mr. A. C. Weeks, and Mr. William Beutenmüller—were published by Dr. Lamborn in a volume entitled "Dragon-Flies vs. Mosquitoes. The Lamborn prize essays." The essays were all excellent. Here, however, they are mentioned, by the way, in connection with the group of the best-known natural enemies of mosquitoes, namely, the dragon flies. It is needless to say that none of the essays were able to solve the problem of a practical breeding, on a large scale, of dragon flies for mosquito extermination, and, in fact, the whole subject of the natural enemies of the mosquito is of little practical importance. It is simply a matter of general interest. Dragon flies, as adults, feed upon adult mosquitoes, just as they will upon all other insects which they are able to capture and devour. Dragon flies, as larvæ, feed upon the larvæ and pupæ of mosquitoes, although other and larger and less active aquatic insects and small fish form the bulk of their food.

The extreme activity of both larvæ and pupæ of mosquitoes is a necessary factor in their struggle for existence, since stagnant pools of water fairly swarm with predatory animal life. The larva of one of the water beetles of the family Hydrophilidæ eats hundreds of other insects in the course of its existence, and the larvæ of mosquitoes do not escape entirely, although by their extreme activity they stand a better chance than do other more sluggish species. A small pool of water on the Department grounds at Washington is situated near a manure pile, and the water is colored dark brown by the drainage from the manure. The pool is kept by Mr. Saunders, the superintendent of the grounds, for the purpose of securing manure water for some of his plants. It is, at all times through the summer,

swarming with the larvæ of *Culex pungens*, *C. stimulans*, and *C. perturbans*; also with the larva of an Ephhydrid—*Brachyleutera argentata* Walk.—and with the larva of an Ephemerid of the genus *Cænis*, and other aquatic species. A number of specimens of Hydrophilid larvæ were found by the writer in this pool. They fed upon the other aquatic insects with avidity, and three of them were placed in a large battery jar with about a half gallon of this water, teeming with insect life and containing apparently some hundreds of the mosquito larvæ and many of the others just mentioned. These three Hydrophilid larvæ, in the course of a week, practically devoured all of the other animal life in the jar. Only two male mosquitoes and one female succeeded in reaching the adult stage.

No one can realize the intensity of the struggle for existence which is going on in a stagnant pool until he forces himself to the seemingly rather unpleasant occupation of lying down by its side and watching with a large hand lens the various forms of life with which the water is swarming. Aside from the larvæ of the dragon flies and the predatory larvæ of the three great families of aquatic beetles, namely, the Dytiscidæ, the Hydrophilidæ, and the Gyrinidæ, there are aquatic neuropteroid insects which are predatory and which feed upon mosquito larvæ as well as others, like those of the genus *Hydropsyche*; and there are aquatic Heteroptera which are also predatory.

Aside from insects, there are many other natural enemies of mosquitoes. Many fish eat their larvæ and pupæ, and such night-flying birds as nighthawks and whip-poor-wills, and bats as well, destroy the adults. Harvey (American Naturalist, 1880, p. 896), quoted by Mrs. Aaron, found 600 mosquitoes in the crop of a nighthawk.

REMEDIES AGAINST MOSQUITOES.

Remedies in houses and the prevention of bites.—Of the remedies in use in houses the burning of pyrethrum powder and the catching of mosquitoes on the walls in kerosene cups are probably the best, next to a thorough screening and mosquito bars about the bed. In burning pyrethrum powder it is well to moisten the powder sufficiently with water so that it can be molded roughly into little cones about the size of a chocolate drop. These cones are placed on a pan and dried in the oven. If ignited at the apex the cones smolder slowly, giving off an odor not unlike that of the prepared punk which boys in this country use to light firecrackers. Two or three of these cones burned in a room in the evening will give relief by stupefying the mosquitoes. This smoke appears to be perfectly innocuous to human beings. The writer has breathed it evening after evening without the slightest perceptible ill effect. The method of catching mosquitoes on the walls with kerosene in cups is now in frequent use in different parts of the

country. No one seems to know who invented it, but the writer first saw it in operation some years ago in New Jersey, and was struck with its simplicity and efficacy. The top of a tin baking-powder box is inverted and nailed to the end of a stick of sufficient length to reach to the ceiling. A small quantity of kerosene is put into this improvised cup and the apparatus is pushed up under resting mosquitoes, which fall into the kerosene and are destroyed. It is the custom in certain houses to systematically hunt for mosquitoes in the bedrooms with such an apparatus every night before retiring.

Camphor rubbed on the face and hands or a few drops upon the pillow at night will keep mosquitoes away for a time, and this is also a well-known property of oil of pennyroyal. The use of oil of peppermint, lemon juice, and vinegar have all been recommended as protectors against mosquitoes, while oil of tar as used against the black fly in Canada is also used in bad mosquito localities. Strongly camphorated vaseline, although recommended, has been found by Dr. Nuttall to be of scarcely any use in Canada.

One of the London papers, the Daily Telegraph, invited its readers to send in mosquito remedies of this kind during the summer of 1899, and some of the substances recommended were as follows:

Eucalyptol on the skin, with a handkerchief saturated with it placed on the pillow at night—the result of South African experience. (Arthur E. Edwards.)

Carbolated vaseline. (Dr. George Mackern.)

One drop of oil of lavender on pillow, and one on the head at night. (A. E. S.)

Tincture of *Ledum palustre*. (M. Fisher.)

Piece of cotton wool soaked in oil of cloves on each side of the bed curtains. (W. B.)

Anoint skin with 3 parts refined paraffin and 1 part crushed camphor. (W. T. Catleugh.)

To heal the bites, a drop of liquid ammonia. (P. G. L.)

Eucalyptus oil. (X.)

Same substance. (Dr. George Cohen.)

Oil of eucalyptus and creosote, each 5 drops, to be thoroughly mixed with 1 ounce of glycerin. (R. R. P. S. Bowker.)

Place a fine, juicy, uncooked beefsteak near the bed on retiring. (M. M. M.)

A substance with which the writer is not familiar, but which is spoken of very highly in the interesting paper by the Italians Celli and Casagrandi in a paper to which we shall have occasion to refer later in speaking of remedies against the larva, is a yellow aniline color, referred to in the work of the Italians as *Larycith III*. They state that a little of this substance burned will kill the adult mosquitoes and that this method constitutes the most efficacious means of destroying them. The Chinese use pine or juniper sawdust, mixed with a small quantity of brimstone and 1 ounce of arsenic, run into slender bags in a dry state. Each bag is coiled like a snake, and tied with thread. The outer end is lighted. Two coils are said to be sufficient for an ordinary room, and 100 coils sell for 6 cents.

Remedies for bites.—Dr. E. O. Peck, of Morristown, N. J., wrote to this office last summer stating that he had found glycerin a sovereign cure for the bites. Touch the bite with glycerin, and in a few minutes the pain is gone. According to Dr. Peck it also took the pain from bee stings. Dr. Charles A. Nash, of New York City, has recently informed the writer, by correspondence, that whenever a mosquito bites him he rubs the spot and marks it with a lump of indigo. This, he says, “instantaneously renders the bite absolutely of no account,” whether the application is made immediately, the next day, or the day after. He has used it since 1878, and lives in a New Jersey town where, he writes, “mosquitoes are a pest every year.” He finds the same application to give relief from the stings of the yellow jacket. Household ammonia has been found by many persons to give relief.

DESTRUCTION OF LARVÆ AND ABOLITION OF BREEDING PLACES.

The following paragraphs are quoted from the writer’s article in Bulletin No. 4:

“Altogether the most satisfactory ways of fighting mosquitoes are those which result in the destruction of the larvæ or the abolition of their breeding places. In not every locality are these measures feasible, but in many places there is absolutely no necessity for the mosquito annoyance. The three main preventive measures are the draining of breeding places, the introduction of small fish into fishless breeding places, and the treatment of such pools with kerosene. These are three alternatives, any one of which will be efficacious, and any one of which may be used where there are reasons against the trial of the others.

“*Kerosene on breeding pools.*—In 1892 the writer published the first account of extensive out-of-doors experiments to determine the actual effect upon the mosquitoes of a thin layer of kerosene upon the surface of water in breeding pools and the relative amount to be used. He showed the quantity of kerosene necessary for a given water surface, and demonstrated further that not only are the larvæ and pupæ thereby destroyed almost immediately, but that the female mosquitoes are not deterred from attempting to oviposit upon the surface of the water, and that they are thus destroyed in large numbers *before their eggs are laid*. He also showed approximately the length of time for which one such treatment would remain operative. No originality was claimed for the suggestion, but only for the more or less exact experimentation. The writer, himself, as early as 1867, had found that kerosene would kill mosquito larvæ, and the same knowledge was probably put in practice, although without publicity, in other parts of the country. In fact, Mr. H. E. Weed states (Insect Life, Vol. VII,

p. 212) that in the French quarter of New Orleans it has been a common practice for many years to place kerosene in the water tanks to lessen the numbers of mosquitoes in a given locality, although he knew nothing that had been written to show that such was the case, and he says: 'In this age of advancement we can no longer go by hearsay evidence.' Suggestions as to the use of kerosene, and even experiments on a water surface 10 inches square, showing that the larvæ could be killed by kerosene, were recorded by Mrs. C. B. Aaron in her Lamborn prize essay and published in the work entitled '*Dragon Flies versus Mosquitoes*' (D. Appleton & Co., 1890). Mr. W. Beutenmüller, also in the same work, made the same suggestion.

"The quantity of kerosene to be practically used, as shown by the writer's experiments, is approximately 1 ounce to 15 square feet of water surface, and ordinarily the application need not be renewed for one month. Since 1892 several demonstrations, on both a large and a small scale, have been made. Two localities were rid of the mosquito plague under the supervision of the writer by the use of kerosene alone. Mr. Weed, in the article above mentioned, states that he rid the college campus of the Mississippi Agricultural College of mosquitoes by the treatment with kerosene of eleven large water tanks. Dr. John B. Smith has recorded, though without details, success with this remedy in two cases on Long Island (Insect Life, Vol. VI, p. 91). Prof. J. H. Comstock tells the writer that a similar series of experiments, with perfectly satisfactory results, was carried out by Mr. Vernon L. Kellogg on the campus of Stanford University, at Palo Alto, Cal. In this case post holes filled with surface water were treated, with the result that the mosquito plague was almost immediately alleviated.

"Additional experiments on a somewhat larger scale have been made by Rev. John D. Long at Oak Island Beach, Long Island Sound, and by Mr. W. R. Hopson, near Bridgeport, Conn., also on the shores of Long Island Sound, the experiments in both cases indicating the efficacy of the remedy when applied intelligently. I have not been able to learn the details of Mr. Hopson's operations, but am told that they included extensive draining as well as the use of kerosene.

"It is not, however, the great sea marshes along the coast, where mosquitoes breed in countless numbers, which we can expect to treat by this method, but the inland places, where the mosquito supply is derived from comparatively small swamps and circumscribed pools. In most localities people endure the torment or direct their remedies against the adult insect only, without the slightest attempt to investigate the source of the supply, when the very first step should be the undertaking of such an investigation. In '*Gleanings in Bee Culture*' (October 1, 1895) we notice the statement in the California column that in some California towns the pit or vault behind water-closets is

subject to flushing with water during the irrigation of the land near by. A period of several weeks elapses before more water is turned in, and in the meantime the water becomes stagnant and the breeding place of millions of mosquitoes. Then, as the correspondent says, 'people go around wondering where all the mosquitoes come from, put up screens, burn buhach, and make a great fuss.' Nothing could be easier than to pour an ounce of kerosene into each of these pits, and all danger from mosquitoes will have passed.

"In many houses in Baltimore, Md., the sewage drains first into wells or sinks in the back yard, and thence in some cases into sewers, and in other cases is pumped out periodically. These wells invariably have open privies built over them, and the mosquitoes, which breed in the stagnant contents of the sinks, have free egress into the open air back of the houses. Hence parts of Baltimore much farther removed from either running or stagnant water than certain parts of Washington, where no mosquitoes are found, are terribly mosquito ridden, and sleep without mosquito bars is, from May to December, almost impossible. Specimens of *Culex pungens* captured November 5 in such a privy as described have been brought to the writer from Baltimore by one of his assistants, Mr. R. M. Reese.

"Kerosene has been tried by Mr. Reese in one case in Baltimore, and two treatments of a privy made about May 1 and June 1, respectively, seemed to diminish the numbers of the pest in that particular house; but without concerted action of all the householders in a given block (all the houses, be it remembered, being exactly alike in the method of sewage disposal) no great amount of good could be accomplished. With such concerted action, however, there seems to be no reason why the mosquito plague could not be greatly diminished in many, if not most, parts of Baltimore at a very small expense. Usually one well serves two houses, the privies being built in pairs, so that one treatment would suffice for two dwellings.

On ponds of any size the quickest and most perfect method of forming a film of kerosene will be to spray the oil over the surface of the water.

"*Drainage.*—The remedy which depends upon draining breeding places needs no extended discussion. Naturally the draining off of the water of pools will prevent mosquitoes from breeding there, and the possibility of such draining and the means by which it may be done will vary with each individual case. The writer is informed that an elaborate bit of work which has been done at Virginia Beach bears on this method. Behind the hotels at this place, the hotels themselves fronting upon the beach, was a large fresh-water lake, which, with its adjoining swamps, was a source of mosquito supply, and it was further feared that it made the neighborhood malarious. Two canals were cut from the lake to the ocean, and by means of machinery the water of the

lake was changed from a body of fresh to a body of salt water. Water that is somewhat brackish will support mosquitoes, but water which is purely salt will destroy them.

“*Practical use of fish.*—The introduction of fish into fishless breeding places is another matter. It may be undesirable to treat certain breeding places with kerosene, as, for instance, water which is intended for drinking, although this has been done without harm in tanks where, as is customary, the drinking supply is drawn from the bottom of the tank. An interesting case noted in *Insect Life* (Vol. IV, p. 223), in which a pair of carp was placed in each of several tanks, in the Riviera, is a case in point. The value of most small fishes for the purpose of destroying mosquito larvæ was well indicated by an experience described to us by Mr. C. H. Russell, of Bridgeport, Conn. In this case a very high tide broke away a dike and flooded the salt meadows of Stratford, a small town a few miles from Bridgeport. The receding tide left two small lakes, nearly side by side and of the same size. In one lake the tide left a dozen or more small fishes, while the other was fishless. An examination by Mr. Russell in the summer of 1891 showed that while the fishless lake contained tens of thousands of mosquito larvæ, that containing the fish had no larvæ.

“The use of carp for this purpose has been mentioned in the preceding paragraph, but most small fish will answer as well. The writer knows of none that will be better than either of the common little sticklebacks (*Gasterosteus aculeatus* or *Pygosteus pungitius*). They are small, but very active and very voracious. Mr. F. W. Ulrich, of Trinidad, has written us that there is a little cyprinoid common in that island which answers admirably for this purpose. This fish has not been specifically determined, but we hope to make an effort to introduce it into our Southern States, if it proves to be new to our fauna. At Beeville, Tex., a little fish is used for this purpose, which is there called a perch, although we have not been able to find out just what the species is. They soon eat up the mosquito larvæ, however, and in order to keep them alive the people adopt an ingenious flytrap, which they keep in their houses and in which about a quart of flies a day is caught. These flies are then fed to the fish. This makes a little circle which strikes us as particularly ingenious and pleasant. The flytraps catch the flies and rid the house of that pest. The flies are fed to the fish in the water tanks and keep them alive in order that they may feed on the mosquito larvæ, thus keeping the houses free of mosquitoes.

“*Artificial agitation of the water.*—Where kerosene is considered objectionable, and where fish can not be readily obtained, there is another course left open. It is the constant artificial agitation of the water, since mosquitoes will oviposit only in still water. At San Diego, Tex., in the summer there are no streams for many miles, but plenty of mosquitoes breed in the water tanks. Some enterprising

individuals kept their tanks free by putting in a little wheel, which is turned by the windmill, and keeps the water almost constantly agitated."

Later use of kerosene.—Since the publication of the recommendations just quoted, a great deal of experimental work has been carried on in different parts of the country, both on a small scale and on large scales. An unfortunate editorial note published in the *American Naturalist* in 1895 states that the writer discovered the kerosene treatment against mosquito larvæ, whereas in his first article on the subject (*Insect Life*, Vol. V, pp. 12 to 14) he began with the words: "One of the most reasonable of the recommendations which have been made from time to time * * * is the application of kerosene to restricted and fishless breeding ponds." The note in the *Naturalist* was the text, however, for a sarcastic note in the *Revue Scientifique*, 1895, Volume IV, page 729, by a writer named Delbœuf, aimed not only against the writer, but against Americans in general. He stated that he had used kerosene as a remedy for fully fifty years, and that its use is referred to in the *Journal Pittoresque* for 1847, page 80, where it is spoken of as something already well known. Since the writer made no claims to any originality, but simply announced exact experimentation upon a somewhat large scale, the matter may rest very comfortably where it is. But it is interesting to note here that as long ago as 1812, in a work published in London under the title "*Omniana or Horæ Otiosiores*," a collection of odds and ends of all kinds, the following suggestion is made:

The mosquito, which is of all the race of flies the most noxious, breeds in the water. Might it not be possible at the seasons when they emerge and when they deposit their eggs upon the surface to diminish their numbers by pouring oil upon great standing water and large rivers in those places which are most infested by them?

The writer is indebted to Mr. D. C. Clark, of Baltimore, for this interesting reference.

During the past few years kerosene has been rather extensively used at many places in an effort to limit the mosquito supply. As already pointed out, there are many places where the source of mosquito supply is definitely limited and easy of treatment, and in such cases on account of the cheapness of kerosene it will be the best means of eradication. In other places where communities are surrounded with swamp land or in the case of extensive sea marshes kerosene can be practically used in connection with other and more elaborate measures, comprehending, as a rule, dyking and draining. At a relatively slight expense, however, a country club on Staten Island has during one season practically stopped the breeding of *Culex pungeus* in ponds and marshes in the vicinity by the use of kerosene alone. This substance has also been used with good effect by the Town Improvement Society

at Summit, N. J., in woodland pools and swamp land, and its use on a large scale is being attempted the present year in the vicinity of a large town on Long Island. Dr. A. D. Hopkins, of Morgantown, W. Va., tells the writer that about ten years ago an extensive pumping station was located near the river bank where the oil pipe line crosses a mile above Morgantown and that the oil frequently escapes out over the river. Since that time the city has been almost exempt from mosquitoes.

In 1897, Mr. M. J. Wightman, while interested in developing a new resort known as Midland Beach, had 4 barrels of crude petroleum scattered over the marshes surrounding the beach. For three weeks previously the mosquitoes had been unbearable. The employees at the beach went about with their heads covered with netting, and of course this had a very discouraging influence upon visitors. The oiled district covered a radius of half a mile, and Mr. Wightman, writing in 1899, stated that within three days after the oil was distributed mosquitoes were rare along the beach. This condition lasted throughout the season. Recently, owing to a change of management, the writer is informed that nothing has been done and that mosquitoes have become plentiful again.

Dr. St. George Gray, of St. Lucia, British West Indies, writes, after reading Bulletin 4 of this office, that he has tried kerosene in his well and in the water jars in his yard with the result that one species has disappeared from his house and that the other mosquitoes give him very little trouble.

The remedial experiments against mosquito larvæ tried by Doctors Stephens and Christopher at Sierra Leone are given in the reports to the malaria committee of the Royal Society, London, July 6, 1900. They selected as the most practical larvicides kerosene (paraffin oil) and salt. The salt, requiring a very strong solution, was not experimented with extensively. A few handfuls thrown into pools containing not more than 3 or 4 pints of water produced no effect in three days. With kerosene the rock pools and small runnels of water were treated: "The larvicidal effect in the pools was very striking, most of the larvæ being killed in fifteen minutes or less. In many cases again, besides the larvicidal effect, adult females were found next day killed by the paraffin on the surface of the pool where they had come to lay their eggs." Thus the writer's 1893 observation on the non-deterrent effect of the kerosene film on adult mosquitoes and their resultant destruction before the eggs are laid is confirmed. This has always seemed to be a point of great practical value in the use of kerosene. The final result by the English observers, however, was found to be the immediate return of the insects on the cessation of the application of petroleum. An interesting test experiment was made by them upon a surface drain arising from a spring and running for 300 yards when it

entered a brook. The spring was free from larvæ, but the drain teemed with them throughout its entire length. Over this drain kerosene oil was sprinkled by means of a watering pot. About 4 gallons sufficed to cover the drain thickly with oil. "The larvicidal effect was immediate, and on the following day no living larvæ were seen. Four days later traces of oil were still present in places. Eight days later small larvæ were present along the whole drain. * * * A weekly application of paraffin then would effectually prevent the formation of the perfect insect in these situations."

The rapid disappearance of the kerosene covering in this last experiment is quite contrary to the results of our applications made to still pools of water. This may have been due in part to the fact that there was more or less of a current in the drain, and may also have been due to the use of an especially volatile kerosene. The writer is now advising the use of the grade known as lubricating oil as the result of the extensive experiments made on Staten Island. It is much more persistent than the ordinary illuminating oils.

An interesting plan, suggested to the writer by Mr. W. C. Kerr, of New York, in conversation, to disseminate oil over salt marshes, was that of putting barrels of oil in the marshes in winter when the ground is frozen and piercing the barrels with small holes so that the oil will escape slowly through the following breeding season. The best method of distributing oil on the surface of water is a practical question which each experimenter is apt to settle for himself. The writer has adopted the plan of simply pouring the requisite quantity of oil upon the water and allowing it to spread by itself, which it does in the course of time. The Staten Island and Summit, N. J., people use a spray pump, but in some ways this seems to the writer not perfectly satisfactory. A great deal of kerosene is apt to be wasted and the continuous layer of oil which is desirable is frequently not brought about. The Liverpool School of Tropical Diseases advises as the result of the Sierra Leone work that the oil can be best applied by smearing the pool with a rag fixed to the end of a stick and dipped in a pot of oil. "In this manner a number of pools can be dealt with in five minutes at the expense of very little oil."

OTHER LARVICIDES.

Permanganate of potash.—Other substances have been experimented with. Two years ago many newspapers contained an item concerning the use of permanganate of potash. As this item was credited to the Public Health Journal it gained a great deal of credence, and was afterwards mentioned in an interesting article by Mr. A. C. Weeks, in the Scientific American. The published note read as follows:

Two and one-half hours are required for a mosquito to develop from its first stage, a speck resembling cholera bacteria, to its active and venomous maturity. The

insect in all its phases may be instantly killed by contact with minute quantities of permanganate of potash. It is claimed that 1 part of this substance in 1,500 of solution distributed in mosquito marshes will render the development of larvæ impossible; that a handful of permanganate will oxidize a 10-acre swamp, kill its embryo insects, and keep it free from organic matter for thirty days, at a cost of 25 cents; that with care a whole State may be kept free of insect pests at a small cost. An efficacious method is to scatter a few crystals widely apart. A single pinch of permanganate has killed all the germs in a 1,000-gallon tank.

The item is so obviously ridiculous upon its face that it would hardly seem worth while to make any attempt to refute its statements. Nevertheless, it has been so widely read that definite experimentation seems necessary to set the matter at rest. The unknown author's ignorance of the life history of mosquitoes in the opening sentence need not necessarily imply that he would not know a good remedy if he found one. Careful experiments were undertaken by the writer in July, 1898, with various strengths of permanganate of potash in water containing mosquito larvæ from one to six days old. It was found that small amounts of the chemical had no effect whatever upon the larvæ, which were, however, killed by using amounts so large that, instead of using a "handful to a 10-acre swamp," at least a wagon load would have to be used to accomplish any result. Moreover, after the use of this large amount and after the larvæ were killed, the same water twenty-four hours later, sustained freshly-hatched mosquito larvæ perfectly, so that even were a person to go to the prohibitive expense of killing mosquito larvæ in the swamp with permanganate of potash, the same task would have to be done over again two days later.

The same conclusion was subsequently reached, after careful experiment, by Dr. Lederle, of the New York health office, and by the Italians Celli and Casagrandi.

Proprietary mixtures.—A number of proprietary and secret mixtures recommended for mosquito-breeding pools and which have been put on the market since the wide-spread interest in the mosquito question has sprung up have been tested by the writer, but none have been found more satisfactory than the cheapest petroleum oil.

Experiments of Celli and Casagrandi.—The most extensive series of experiments with culicidal mixtures which has been made was conducted by the Italians Celli and Casagrandi, above referred to. They have tabulated in the "Annali d' Igiene Sperimentale, Rome (Vol. IX, Fasc. III, 1899, pp. 317-353), the results of experiments with many substances. Referring to petroleum, they say that apart from the question of the expense, which outside of America is worthy of note, the action of petroleum in destroying mosquito larvæ is not always to be put in the front rank. Their conclusions are practically as follows:

(1) Of the whole period of the cycle of development of mosquitoes the stages in which they are most easily destroyed are those of larvæ and of the aerial mosquito, and larvæ are most easily killed the younger they are.

(2) To kill the larvæ, among numerous substances experimented with, there will have, in decreasing order, culicidal action: (a) Mineral: sulphurous oxide, permanganate of potash with hydrochloric acid, common salt, potash, ammonia, carburet of lime, corrosive sublimate, chloride of lime, the bisulphites, sulphate of iron or copper, lime, bichromate of potash, and sodium sulphite. (b) Organic: powders of the unexpanded flowers of chrysanthemum, tobacco, petroleum and oils, formalin, creso-, certain aniline colors (gallot, green malachite), coal tar. Taking into account, however, the dose necessary to kill the larvæ, the practicability and the price, all of the mineral and some of the organic substances are excluded, and there remain as available the vegetable powders, petroleum, and the aniline colors.

(3) To kill aerial mosquitoes, we have odors, fumes, or gases. Among the odors are turpentine, iodoform, menthol, nutmeg, camphor, garlic. Among the fumes are tobacco, chrysanthemum powder, fresh leaves of eucalyptus, quassia wood, pyrethrum powder. Among the gases, sulphuric oxide. It is, however, to be noted that for these odors, fumes, or gases to exercise their culicidal action they must fill or saturate the whole ambient; otherwise they produce only apparent death, or at most only a culicifugal action, which sometimes in houses may be useful in protecting man from being bitten by mosquitoes, and preventing the latter infecting him when they have sucked the blood of malarious persons.

(4) The problem of the destruction of mosquitoes is experimentally soluble, but practically it will only be so when economic interests desire it. In this latter sense it is remarkable that the old larvicidal use of petroleum has not become much diffused in those places where it is very cheap. The chrysanthemum plants might be grown on a large scale, this making the malarial place itself produce that substance which frees it of the mosquitoes that infest it.

(5) The opportune season for killing the larvæ is in the winter, when they are in least numbers in the waters and new generations are not born; this also is the season for their destruction in houses, for they come here for a warmer abode. Their habits and places of nesting should be studied to this end. This may not be accomplished on a large scale as easily as some boast; nevertheless, after the treasures spent by nations and individuals for preserving vines and vegetation from the oidium, the peronospora, and the phylloxera, we may hope that something may be done for protecting the life of man from the mosquitoes of malaria.

It will be noticed that they really exclude from further consideration all substances except vegetable powders, petroleum, and the aniline colors. By vegetable powders they refer to the powders from the flowers of plants of the genus *Pyrethrum*, and their experiments upon the aniline colors practically center upon the recommendation of the substance already referred to as the yellow aniline dye which they call "Laryeith III." This color has the property of other aniline colors in that it is soluble and diffusible in water. The practice recommended is to make a concentrated solution, which is poured into the pool or pond to be treated. It is said by the authors that it will destroy all insect life and fishes, but is harmless to warm-blooded animals; thus domestic animals may, without danger, drink from pools being treated.

Just what "Laryeith III" will prove to be and whether it will be available for use in this country unfortunately can not be ascertained at the present moment. Correspondence has been entered into with large dye firms in New York who have sent abroad for information.

Dr. Ross, in his article in *Nature* of March 29, previously referred

to, says: "On the whole, the most promising method which suggests itself is the employment of some cheap solid material or powder which dissolves slowly, which kills the larvæ without injuring higher animals, and which renders small pools uninhabitable for the larvæ for some months. If, for instance, a cartload of such material would suffice to extirpate the larvæ over a square mile of a malarious town, the result would be a large gain to its healthfulness. Dr. Fielding-Ould has lately reported favorably on tar."

Tar and its compounds.—Again, in the report of the Liverpool School of Tropical Diseases the following words occur: "Perhaps more permanent oil than kerosene would be more permanently effective. Fresh tar dropped in a puddle makes a film like that of oil and has been favorably reported on. Quicklime has been suggested, and all these should certainly be tried."

The writer is rather at a loss to know exactly what is meant by the expressions "fresh tar" and "tar" in the above paragraphs. He has conducted an experiment, however, with a substance known to the trade as "coal tar," a thick viscid liquid. A few large drops of this substance were dropped into a glass vessel containing approximately 2 quarts of water in which were more than 100 full-grown larvæ of *Culex*. All the drops but one sank at once to the bottom, the last one floating upon the surface for some time. No surface film seemed to form from the tar, but after the expiration of forty-eight hours the water was found to be more or less impregnated by the tar, having turned somewhat darker in color, while the odor of the tar was perceptible. At the expiration of five days nearly all the *Culex* larvæ were dead; 1 had succeeded in transforming to pupa, and 5 or 6 remained at the surface enfeebled and dying. Thus more than 95 per cent had been killed. In the meantime, however, twenty-four hours after the experiment began, 3 egg masses were laid on the surface of the water by outside females of *Culex*. These had hatched in forty-eight hours more, and on the fifth day, although the original full-grown larvæ were practically exterminated, many young larvæ were swarming actively about in the tar water. They continued to grow and to remain apparently perfectly active and healthy, although the odor of the tar was distinctly perceptible and the color of the water was dark, and even a thin oily film remained over a portion of the surface.

From this experiment it was plain that the killing effect of the tar in the preparation used is comparatively fugitive, and it was next decided to test some of the coal-tar products. The object of this line of experimentation was not only to test the suggestions of the English observers, but also on account of the fact that as almost every community manufactures its own illuminating gas it was considered an easy and probably economical way of securing a mosquito larvicide, if it should prove to be effective. Coal tar is distilled into various grades

of oil, and two of the heavier of these grades were used in the succeeding experiments. One of these was called "creosote oil," and was a rather light oil of a specific gravity of 1.035 at 60° F., and the other, bearing no name, was somewhat heavier. The experiments were necessarily on a somewhat small scale. Eighty nearly full-grown larvæ of *Culex stimulans* and *C. perturbans* were placed in 3 quarts of water and one-fourth ounce of creosote oil was poured in at 4.15 p. m. At 5.45 17 pupæ and 3 larvæ were left alive. The next morning at 9 o'clock it was found that 8 adults had issued over night, but all had been killed by the creosote. At 3 p. m. of the same day, twenty-three hours after the introduction of the insecticide, all larvæ and pupæ were dead. With the slightly heavier oil, 150 larvæ of the same species, all full grown or nearly so, were placed in 2 quarts of water and three-sixteenths ounce of the oil was added at 4.15 p. m. At 5.45 all were dead except 28 pupæ and about 30 larvæ. The next morning at 9 o'clock it was discovered that 10 adults had issued over night, but had been killed before flight by the oil. At 4.30 p. m. of the same day all the larvæ were dead, but 10 pupæ were still active. On the following morning, at 9 o'clock, forty-two hours after the application, all larvæ were dead and the adults had issued from the remaining pupæ, but had been caught by the oily film in the act of issuing and had died upon the surface of the water.

Still another experiment was tried with pupæ only. Two hundred and fifty pupæ of the same *Culices* were placed in 3 quarts of water and one-fourth ounce of creosote oil was added. Twenty hours later many of the pupæ were still living, but thirty-six hours from the time of application all were dead, no adults having issued. A check experiment with kerosene was carried on parallel with this last experiment with creosote, and it was noticed that the action of the kerosene upon the pupæ was much quicker, all dying within forty-five minutes. A few young larvæ, however, in the same jar lived for several hours.

An interesting effect of the application of the creosote in the first two of these experiments was that it seemed without doubt to hasten the transformation of the insect. When at 4.15 the creosote was poured in jars 1 and 2, no pupæ were observed, but all larvæ were full grown or nearly so. After fifteen minutes 10 pupæ were observed in jar 2 and 5 in jar 1. Ten minutes later 15 were counted in jar 2 and 13 in jar 1. Twenty minutes later there were 19 in jar 2 and 22 in jar 1. Fifteen minutes later still there were 19 in jar 2 and 22 in jar 1. Thirty minutes later there were 17 in jar 2 (2 having died in the interval) and 28 in jar 1. As above stated, over night a number of adults issued, 10 in jar 1 and 8 in jar 2, and twenty-four hours later 10 more adults issued in jar 1. It must be remarked that the full-grown larvæ struggled violently on perceiving the uncomfortable presence of the creosote, and as they were just ready to transform this

violent struggling evidently assisted in the breaking of the larval skin, leaving the pupa bare. This transformation from larva to pupa is hardly as interesting as the rapid development of adults, 18 of which issued within fifteen hours after transformation to pupa, whereas previously the shortest duration of the pupal state which we had observed was forty-eight hours. It looks like an effort of nature to perpetuate the species in the presence of a unique emergency.

On the whole, the result of the experiments with tar and tar oils was rather unsatisfactory as compared with the heavier grades of kerosene. The effect of the tar was not permanent, and the effect of the creosote oils was not as rapid as that of kerosene, and the writer is inclined to the opinion that the heavier grades of kerosene oils are, on the whole, preferable, although the effect of the creosote oils is very good, and they can be used to advantage. He is inclined to think that they may prove to be more permanent, although not quite so rapid in their effect, than the lighter illuminating oils.

EUCALYPTUS TREES.

In addition to the use of eucalyptus oil on the skin to keep mosquitoes from biting, the growth of eucalyptus trees is said by certain persons to drive mosquitoes away, and trees of the genus *Eucalyptus* have been especially recommended for planting in malarial regions. Mr. Alvah A. Eaton, of California, wrote us in 1893 that in portions of California where the blue gum occurs no other remedy need be sought for. Further than that, he stated that no matter how plentiful the mosquitoes, a few twigs or leaves laid on the pillow at night would secure perfect immunity. The same year Mr. W. A. Sanders, of California, sent the following interesting account of the value of eucalyptus trees in answer to our published request in *Insect Life*:

I have the largest and oldest grove of trees of *Eucalyptus globulus* in this part of California, and have had fifteen years of opportunity to study these trees as insect repellants, and deem it my duty to respond to your request on page 268 of *Insect Life*.

Thirty-three years ago I spent a portion of one summer with a Dr. McConnell, who had just returned from some years of residence among the Eucalyptus forests of Australia. We were in the Sequoia (*Sequoia sempervirens*) forest of the coast region of our State. The mosquitoes were so bad that it was nearly impossible to work during days when there was no wind. The doctor assured me that our common mosquito was never found in the Australian Eucalyptus forests and swamps, but added, There's a "spotted mosquito" nearly as bad there in some places. He, not being an entomologist, was unable to tell me whether the "spotted mosquito" was a species of the genus *Culex*, or of some allied genus.

The doctor being a reliable, close observer, I determined to test the antimosquito qualities of the Eucalyptus; so when I began to improve my house here nineteen years ago, one of the first things I did was to get a lot of eucalyptus seed from Australia and plant out a grove of the trees. The tallest of them are now over 140 feet tall, and can be seen for 20 miles around. My house stands in the midst of these

trees. My irrigating ditch, a dozen feet wide, of sluggish current, runs through the grove beside the house. There has never a single mosquito larva been seen in the ditch from where it enters the first shade of these trees to where it emerges from them 200 yards away, while above and below mosquito larvæ are plentiful—not immediately below, but some hundreds of yards away, where the water stands in pools and becomes stagnant among a growth of black walnuts and cottonwoods.

My live stock pasture in this timber, going into the walnuts and back again under the eucalyptus shade at pleasure. Frequently when the cows come up at night they bring a swarm of mosquitoes; occasionally some of them get into the house, but cause us so little annoyance that we scarcely notice them. Before this ditch reaches the Eucalypti it runs through a jungle of "fence bamboo" (*Arundo macrophylla*), where the mosquitoes are so bad that we avoid working there except on the windiest days. And, though the ditch has more current there, the larvæ of mosquitoes are plentiful in the water till it reaches the Eucalyptus trees, below which point none are found till it has become stagnant away below them.

People who have camped along the willows of Kings River, only a few miles away, have come here with faces so blotched and swollen from mosquito bites as to be hardly recognizable, and have camped in the shade of "Sanders's gum trees," as my grove is popularly called, for weeks, and declare that they never even heard a mosquito sing during that time.

To the non-botanical reader I may say that this species of Eucalyptus is very tender to frost. The coldest weather ever known here, 19° F. above zero, killed thousands of them.

Dr. Nuttall points out that the planting of eucalyptus trees is not a sovereign remedy, from the fact that malaria still prevails at Tre Fontane, outside of Rome, in spite of Eucalyptus plantings. The mere planting of trees, however, is undoubtedly of use in malarial districts, since it will modify the condition of drainage of the soil. In view of Mr. Sanders's strong evidence it really appears that planting of eucalyptus trees will be worth while in certain locations, not entirely (on account of the conflicting and not thoroughly satisfactory evidence) for mosquito protection, but incidentally for this use as well as other purposes.

DRAINAGE AND COMMUNITY WORK.

After all, the best of the means which may be adopted against mosquitoes will always consist in the abolition of their breeding places. Small pools with stagnant water can be treated, but it is a great deal better to drain them or to fill them up. Swamp areas must sooner or later be drained. It is perfectly obvious that the sooner this is done the better from every point of view, not only from that of human health but from the increased value of real estate in the neighborhood and from the practical value of the reclaimed land itself. The time is coming, and rapidly, when this drainage of large swamps will not remain a matter which concerns the individual owner of the land, but one for town or county action, and even for States. The report of T. J. Gardner on the policy of the State respecting drainage of large swamps, published in the Report of the Board of Health for New York,

Albany, 1885, although antedating the recent important mosquito discoveries, is well worth reading by all public-minded persons, and the annual reports of the State geologist of New Jersey for 1897 and 1898, in which the reclamation of the great Hackensack Meadows, near Jersey City, Newark, and Elizabeth, N. J., makes interesting reading along this line. Work on these marshes has actually been begun. The solution of this case is taking the form of separate action by cities and their municipalities, each improving the territory within its corporate limits. The city of Newark has a tract of 4,600 acres of marsh within its limits; Jersey City has within its limits 2,086 acres of tide marsh, and Elizabeth has 2,658 acres. The three cities, therefore, have about 8,700 acres of the 27,000 acres lying between Elizabeth and Hackensack. The sanitary importance of reclaiming these lands is of the greatest, but the capabilities of the improvement plans are attracting attention on the part of capitalists and business men, who see in these tide lands valuable sites for manufacturing, industrial, and commercial activity.

Even to individual land owners of a community, the drainage of swamps and the consequent abolition of mosquitoes will in many cases become well worth while. The writer knows of a town in New Jersey, with a good elevation, within easy distance of New York, and admirably adapted for summer residences of New Yorkers, where the mosquitoes are so abundant as to prevent the rise in the price of real estate. An examination of the surrounding country has convinced him that if the large real estate owners were to club together they might, by the expenditure of a few thousand dollars, largely do away with the mosquito plague. Another case which is well worth specific mention, and the truth of which the writer will vouch for, may best be told in the words of a correspondent, printed in one of the Flushing papers late in March:

In the town of Stratford, Conn., where I have resided for the past forty-five years, we have been greatly plagued by swarms of mosquitoes, so great, in fact, that the "Stratford mosquito" became a well-known characteristic of Stratford. We have in the southern part of our town, bordering on the sound, several acres of marsh land or meadow, which would become periodically overflowed with water in the summer and a tremendous breeding ground for mosquitoes, and this plague to the town continued until about 1890-91, when a party from Bridgeport, Conn., purchased a large section of the meadows and began to protect them by a dike, both on the north and south ends, which shut out the water. In addition to this, numerous drain ditches were made, which helped to carry the water away. The result of this work made the land perfectly dry and spongy, so that after a rain no pools collected on the surface of the meadow and prevented the creation of the mosquitoes. The transformation was so remarkable that people outside the town would hardly believe that it had been effected, and a year or two later the town voted a special appropriation of \$2,000 to the party who undertook to build the dike and render the meadows mosquito proof. It had also the effect of placing on the market a large tract of land elevated from the sound for residences, and as many as 25 summer residences have

been built upon this land bordering the sound, and are increasing each year. They are free from mosquitoes, so that the operation shows the economy and the benefit that will result by using some means for eliminating the mosquito-breeding pools.

As to community work, we must not fail to mention the interesting fact that the city of Winchester, Va., is reported to have passed an ordinance requiring property holders to treat drains and stagnant pools of water with kerosene during the summer season. Winchester is a town of high elevation and has for a long time enjoyed a reputation among Virginians as a cool place to spend the summer. Mosquitoes, we are told, however, made their appearance there a few years ago, with the effect that summer visitors became fewer and fewer. The passing of the city ordinance was deemed a matter of public policy and met with general approval. Police measures of this kind may not be inadvisable under certain circumstances. Surely in such instances as the Baltimore case, mentioned in previous pages, it seems entirely appropriate that the board of health should be called upon to enforce kerosene treatment.

APPENDIX.

AN EARLIER ACCOUNT OF THE LARVA OF ANOPHELES.

Just as this manuscript was about to be sent to the printer the writer's attention was called to a paper by F. Meinert, entitled "Die encephale Mygellarver" (Sur les larves encéphales des Diptères; leurs mœurs et leurs métamorphoses). K. Danske Videnskabernes Selskabs Skrifter (Copenhagen), iii. pp. 373-493, Pls. I-IV (1886), in which, among other observations, he gives a brief statement concerning Anopheles which is sufficiently interesting to translate:

"*Anophles*.—In the 'Observations d'Histoire Naturelle' of Joblot one finds a description of this larva, "Description of a new fish," which is rather insignificant, and a drawing which is not badly done. The larva drawn by Brauer as Anopheles is a larva of Dixa, and those reported by Fischer d'Waldheim as *C. dariger* are larvæ and nymphs of the genus Corethra, while his nymph is a Tanypus, and his fly an Anopheles. Aside from this, Gerke has briefly mentioned this larva in his paper entitled 'On the metamorphoses of the dipterous genus Dixa,' page 166.

"The larva of Anopheles lives in still waters or in a weak current with a rich vegetation, in wooded or unwooded regions. It does not like the shade of great trees, but seeks the sun and the light, as is indicated by its fresh green color. It does not hibernate, but in mild seasons it is found in a half-grown condition by the end of March. In July or a little later in the course of a summer the second generation of the full-grown larvæ are found, and in 1882, a year when the spring was very forward, the writer found at the end of October small larvæ which certainly belonged to the third generation; but it was not to be supposed that these larvæ would become full grown, since as they live at the surface of the water the first film of ice would kill them.

"The larvæ hold themselves at the surface of the water, where they float with the extremity of the abdomen turned toward the bank or toward the plants which cover the surface. The larva is stretched out in the water with the respiratory tube at the surface. The larger part of the abdomen and posterior part of the thorax are submerged, only a little portion of the prothorax emerging. The head is under water. The long hairs with which the body of the female is provided on the sides, on the metathorax, and the first three segments of the abdomen are of great assistance to it in maintaining a fixed position. It rests often for a long time immovable and only occasionally changes its location. Its movements denote a certain apathy or indolence, but at the same time much prudence and apprehension. When it moves it

moves rapidly and dives to the bottom of the water. Recovering from its fright, it rises obliquely to the surface.

Just as with the larvæ of *Culex*, the larvæ of *Anopheles* live upon organic microscopic particles which float upon the water, and which are brought into the mouth by the movements of the rotatory organs. These organs are much more developed than with the larvæ of *Culex*, and while they serve, like the former, as a brush or sieve to strain their food the larvæ of *Anopheles*, like those of *Simulium*, holding the head stretched forward, use them to agitate the water. The larvæ of *Anopheles* present this peculiarity, that in producing these currents, which they do the greater part of the day, they lie upon the belly with the under part of the head turned upward. This rotation of the head is executed with the greatest rapidity; and scarcely, for example, have the larvæ come to the surface to float, when, by a rotation of the head upon its longitudinal axis, it is turned bottom side upward and commences to agitate the surface of the water. This agitation is undoubtedly for the purpose of drawing floating objects surely and completely into the orifice of the mouth. This, however, is not necessary, for often one sees the larva with its head working in normal position, mouth organs below, but in general they do not remain in this position for a long time, and it is only after having turned the head upward that they seem to work *con amore*.

As a rule the larvæ seek their nourishment while they are floating at the surface, but at other times they descend two or three inches under the water. They can rest several minutes in this position with the head below, after which they come to the surface again."

This account shows that Meinert knew the larvæ very well, and one can only regret that he did not describe the eggs and the pupæ.

THE MALARIAL EXPEDITION OF THE LIVERPOOL SCHOOL OF TROPICAL MEDICINE.

This interesting and most valuable report was known to the writer only by brief newspaper notes until the present bulletin had reached page proof—too late to insert in proper place several important observations made by Ross, Annett, Austen, and Fielding-Ould. To-day (August 13) it has reached him in Volume II of the Thompson Yates Laboratory Reports (University Press of Liverpool, 1900), and he is glad of the opportunity to add the following paragraphs quoted from its pages:

8. METHODS FOR ASCERTAINING DEFINITIVE HOSTS.

The long researches of one of us in India, followed by those of Koch, Daniels, and the Italian investigators, have given us a very exact knowledge of the life history of the *Hæmaphysidæ* in gnats, and have shown us how to detect them in the insects with ease and certainty. It has been noted that in inhospitable species of gnats the ingested parasites perish within the stomach cavity, whereas in hospitable species the zygotes escape from that cavity and develop in the tissues, ultimately giving rise to blasts which are found in the juices and salivary glands of the insect. * * *

We made the following observations:

(1) *Eggs*.—These are *boat-shaped*, like those of *Anopheles* observed in India. They appear to be laid singly on water, but cohere by their ends, forming typical triangular patterns, and also adhere to floating objects, the sides of the vessel, etc. We observed no facts indicating that they are ever laid on solid surfaces. *In vitro* they take about twenty-four hours to hatch, but the period is probably much shorter in puddles.

(2) *Duration of larval stage*.—This depends on temperature and amount of food. Under natural conditions it may probably be only three or four days, but under unfavorable conditions (cold, overcrowding, absence of food) it may certainly extend to weeks.¹ There are reasons for thinking that development is much hastened by bright weather, in order to enable the imago to hatch out before desiccation of the containing puddle.

(3) *Food*.—The larvæ were frequently watched floating on the surface and feeding on filaments of waterweed, amongst which they often entangle themselves. On dissection the intestine was found crammed with these filaments. It was observed that *in vitro* the larvæ scarcely grow in size unless they are given large quantities of waterweed, which they dispose of very rapidly. On the other hand, larvæ were often caught in puddles in which no green vegetation could be seen. They may eat other food, but it would seem as if waterweeds constitute their favorite diet. It was also noted that they obtain shelter among these weeds from the current running through the pools during or after rain.

(4) *Enemies*.—No observations could be made under this head, but we often found many frogs and tadpoles in the breeding pools, apparently living at peace with the larvæ.

(5) *Effects of desiccation*.—During most of our stay in Freetown heavy showers fell several times a day, so that the larvæ could live secure from desiccation in all but the most evanescent puddles. In September, however, there was a complete break in the rains, lasting three days. A large number of the pools, even many of those containing waterweed, and those fed by springs during rain, dried up completely. The question whether the larvæ had the power of living in the mud at the bottom of the pools could now be tested by direct observation. The break in the rains was followed by heavy showers, which immediately refilled all the puddles. Had the larvæ continued to exist in the mud, they would now have emerged again. As regards the puddles in which the mud had completely dried, this was not the case. No larvæ at all were found in them for at least two days after the rain had refilled them. After that interval larvæ again appeared, but they were very small ones, evidently just hatched from the egg. On the other hand, it was frequently observed that if the mud did not become completely dry, the larvæ would emerge into active existence after another shower. These observations were supported by some experiments *in vitro*, and we therefore conclude that the larvæ can withstand partial, though not complete, desiccation.²

(6) *The same puddles constantly occupied*.—We have suggested (paragraph 13) that the position of the breeding pools may change according to the seasons, but while we were in Freetown there was no change of season, and we generally found *Anopheles* larvæ in the same puddle, namely, in those which were suitable for them. Thus, of two puddles lying close together, one would never contain larvæ and the other would always contain them. The explanation of this probably is that the larvæ

¹ One of us kept *Culex* larvæ alive for two months in a bottle in the cold weather in India.

² One of us reared adults from full-grown larvæ kept on damp blotting paper (in India), but found that the young larvæ died when kept under these conditions.

perish in the unsuitable pools, or that the adults generally return to the same pools in order to lay their eggs. It seems likely that the adults generally lay their eggs in the pools in which they themselves were bred, and that the insects thus learn by experience the places most suitable for them.

(7) *Detection*.—It is easy to overlook *Anopheles* larvæ unless they are searched for in a bright light.

(8) *Pupa*.—The pupæ of *Anopheles* seem to be smaller than those of the commoner species of *Culex*. They require about forty-eight hours to reach maturity *in vitro*; perhaps less in natural conditions.

16. BIONOMICS OF ADULT ANOPHELES.

(1) *Hatching*.—The adults generally hatch out in the evening; but their exit seems often to depend on the meteorological conditions of the moment, and appears to be delayed by rainy and windy weather.

(2) *Food*.—They can easily be kept alive in glass cages, test tubes, bottles, etc. We kept some in this manner for a fortnight, and could doubtless have kept them longer if we had wished to do so. We are able to confirm Bancroft's statement (18) that gnats feed on bananas; but they seem to prefer the fresh fruit. During the day the insects remained at rest on the walls of the cage, but in the evening began to fly about and to walk over the fruit, plunging their proboscis into it in many places, so that the banana was sometimes covered with gnats, both male and female. They also drink water frequently, and each can often be seen to be distended with the fluid. Raw meat was offered to them, but they could not be observed to touch it. Earth placed at the bottom of the cage seems to be suitable for them.

According to the accounts of the soldiers at Wilberforce, they bite almost entirely in the evening and night, but have been known to feed on men during the day. They can certainly be fed on men artificially during the daytime, simply by placing them in test tubes and then applying the mouth of the tube to the skin. The stomach can be observed to become distended in from one to two minutes or more; after which the insect continues to suck, but commences to evacuate by the anus serum containing a small percentage of red corpuscles. *Culex* voids only a clear fluid under the same circumstances. The insects sometimes continue sucking like leeches for five or ten minutes, voiding blood all the while; but at other times soon withdraw the proboscis and then try another spot. It was noted, however, that *Anopheles* fed in this manner, even after they had remained sucking for five or ten minutes, never showed any great distension of the abdomen; while the contents of the stomach still remained for some time transparent and red as seen through the scales of the living insect. Moreover, in these cases the meal was generally digested or voided within about twenty-four hours.

On the other hand, *Anopheles* which had fed themselves under natural conditions generally presented a very different appearance. They were enormously distended; while the contents of the stomach were thick, opaque, and black, and sometimes did not disappear for three days. The only inference is that, under natural conditions, the insects which can manage to do so gorge themselves over and over again during the night—probably from the same subject.

(3) *Propagation*.—We also observed that while naturally fed gnats invariably laid eggs after two or three days, those which had been bred from the larvæ in captivity, and had then been isolated and fed in test tubes, never did so, although before being isolated they had long been in company with males. The inference is that fertilization takes place only after the female has been fed.

We noted also that in a cage where many male and female gnats, *Culex* and *Anopheles*, were kept together for weeks eggs were never laid, although the insects were fed as described on bananas, and the cage contained water for them to lay their eggs in. It seems, then, that a meal of blood is necessary before fertilization.

Lastly, we observed that previously fed and fertilized insects would lay a second batch of eggs after a second meal of blood without a second fertilization, but never laid a second batch of eggs without a second meal of blood. That is, one fertilization suffices for several batches of eggs, but one meal of blood for only one batch of eggs.

These observations are wholly in accord with the results of the prolonged study of many kinds of gnats made in India by one of us; and it therefore seems likely that the following law is likely to hold good for the *Culicidæ* which feed on men, at least for the commoner species.

Although these gnats can live indefinitely on fruit and perhaps juices of plants, the female requires a meal of blood, both for fertilization and for the development of her ova. In other words, the insects need blood for the propagation of their species.

Blood was never found in male *Culicidæ* in Freetown, according with the general law.

(4) *Haunts*.—The large majority of *Anopheles* caught by us in dwellings were females which were generally much gorged, and, if fed at all, were invariably fertilized; in other words, the males and unfed, or only slightly fed, females do not generally remain in the houses during the daytime, or if they did remain, kept in the roofs or other dark places where they were little observed. On the whole, we think that only those females which are so gorged that they can not fly far remain in the houses during the day. We observed that if a cage full of *Anopheles* was disturbed in the daytime, the insects always struggled toward the light as if to fly out from the windows, and several which escaped from the cages actually did so. On one occasion a large number escaped from their cage during the night in the rooms occupied by one of us; none of them could be seen next morning.

Yet we may be quite sure that both the males and the unfed females haunt the houses during the night. The invariably fertilized conditions of the gorged females caught in the houses show that the males must be present in the houses when the females feed, since the latter are often so much distended after feeding that they are obviously unwilling to fly even a few feet from the bed of their victim; in other words, fertilization must take place within the houses. The unfed females must, of course, resort to human habitations during the night in order to obtain their food at all.

These facts would seem to indicate that in Freetown in the rainy season the *Anopheles* resort to the houses during the night, but that all except the gorged females live elsewhere during the daytime—possibly sleep in the trees and shrubs. The point is of interest as tending to show that large numbers of *Anopheles* may be present in a dwelling during the night, without it being easy to find them during the day.

It should, however, be added that in India males and unfed females were often found in the houses in large numbers by one of us. Possibly different species have different habits in this respect.

Several old residents of the country informed us that gnats are usually very prevalent in the presence of much vegetation—especially long grass and undergrowth. Though it is difficult to see how such can favor the larvæ, we can understand that much vegetation can shelter the adults of certain species, which may even feed on particular kinds of plants when they can not obtain blood, and may consequently find it easier to live where these plants afford them both food and shelter than elsewhere. It must also be remembered that gnats can certainly bite birds and other mammalia besides man; and that such are apt to congregate where there is much vegetation. On the whole, then, there is nothing improbable in the idea that the Freetown *Anopheles* should live outside the houses in the daytime.

BULLETIN No. 26—NEW SERIES.

U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF ENTOMOLOGY.

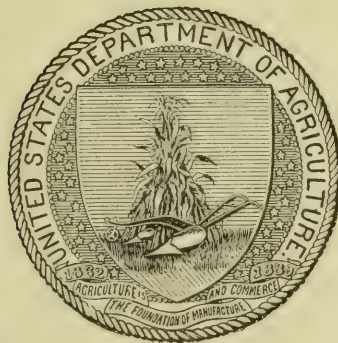
PROCEEDINGS

OF THE

TWELFTH ANNUAL MEETING

OF THE

ASSOCIATION OF ECONOMIC ENTOMOLOGISTS.



WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1900.

DIVISION OF ENTOMOLOGY.

Entomologist: L. O. Howard.

First Assistant Entomologist: C. L. Marlatt.

Assistant Entomologists: Th. Pergande, F. H. Chittenden, Frank Benton.

Investigators: E. A. Schwarz, D. W. Coquillett.

Assistants: R. S. Clifton, Nathan Banks, F. C. Pratt, Aug. Busck, Otto Heidemann,
A. N. Caudell, J. Kotinsky.

Artist: Miss L. Sullivan.

BULLETIN No. 26—NEW SERIES.

U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF ENTOMOLOGY.

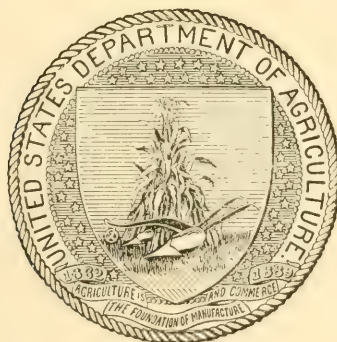
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1900.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,

DIVISION OF ENTOMOLOGY.

Washington, D. C., September 7, 1900.

SIR: I have the honor to transmit herewith the manuscript of the proceedings of the twelfth annual meeting of the Association of Economic Entomologists, which was held at New York City June 22 and 23, 1900. From the fact that the papers presented at the meetings of this Association are always of the greatest economic importance, the Department has hitherto published the secretary's reports as bulletins of this Division. I therefore recommend the publication of the present report as Bulletin No. 26, new series.

Respectfully,

L. O. HOWARD,
Entomologist.

Hon. JAMES WILSON,
Secretary of Agriculture.

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*Withdrawn for publication elsewhere.

TWELFTH ANNUAL MEETING OF THE ASSOCIATION OF ECONOMIC ENTOMOLOGISTS.

MORNING SESSION, FRIDAY, JUNE 22, 1900.

The Association met in room 618, Schermerhorn Hall, Columbia University, New York City, at 10 a. m., June 22, 1900.

The following members were in attendance at the sessions:

Vice-President C. P. Gillette, Fort Collins, Colo.; Secretary A. H. Kirkland, Malden, Mass.; A. F. Burgess, Malden, Mass.; R. S. Clifton, Washington, D. C.; J. H. Comstock, Ithaca, N. Y.; E. P. Felt, Albany, N. Y.; H. T. Fernald, Amherst, Mass.; James Fletcher, Ottawa, Canada; A. D. Hopkins, Morgantown, W. Va.; L. O. Howard, Washington, D. C.; W. G. Johnson, College Park, Md.; Trevor Kincaid, Seattle, Wash.; C. P. Lounsbury, Cape Town, South Africa; A. L. Quaintance, Experiment, Ga.; F. W. Rane, Durham, N. H.; E. D. Sanderson, Newark, Del.; W. M. Scott, Atlanta, Ga.; Franklin Sherman, jr., Ithaca, N. Y.; C. B. Simpson, Ithaca, N. Y.; Henry Skinner, Philadelphia, Pa.; E. B. Southwick, New York City; F. M. Webster, Wooster, Ohio; C. M. Weed, Durham, N. H.; C. W. Woodworth, Berkeley, Cal.

In the absence of President Bruner, Vice-President Gillette called the meeting to order, and asked Mr. Howard to take the chair.

Vice-President Gillette read the following address:

OBJECTS OF THE ASSOCIATION OF ECONOMIC ENTOMOLOGISTS.

By CLARENCE P. GILLETTE, *Fort Collins, Colo.*

No one regrets more than myself that our honored president and genial friend, Professor Bruner, has found it impossible to be with us on this occasion, or to prepare an address for our instruction and entertainment.

It is at the request of Professor Bruner and our worthy secretary that I am offering this hastily prepared substitute for a presidential address, that we may appear to live up to our constitution and time-honored custom.

While it is no small task that is placed upon me, I am mindful of the fact that it is no small honor to be permitted to deliver the opening address of the Annual meeting of this Association of earnest scientific workers—the first and only society of its kind in all the world. Particularly am I impressed with the honor when I remember we are met in one of the foremost seats of scientific learning in our country.

And then there is, perhaps, a sort of grim satisfaction in the feeling that it is my unquestioned privilege at this time to act the part of an adviser. I can praise you for your well-doing, scold you for your shortcomings, and inflict upon you my own ideas as to what your duties are to one another and to the people you serve. But, alas, how often we find that what we supposed to be a new idea or a new species turns out, after all, to be old. After reading again the addresses of former presidents of this Association, it appears that my supposedly new ideas have nearly all been "preoccupied." So I can not hope to offer much at this time that shall be considered new or worthy of specific rank.

Like a freeborn American citizen, I have decided to speak of the duties and privileges conferred upon us by section 2 of our constitution, which sets forth the objects of the organization.

It is well to pause occasionally in our onward career and ask ourselves why we exist. The founders of this Association had high and noble ideas as to what should be attained by its members. In recounting these objects it will be necessary to repeat much that has already been given in addresses of this nature, but will it not be better to urge the performance of duties that have already been recognized as such than to advance many new plans of work to be neglected and soon forgotten?

Section 2 of the constitution gives the objects of the Association in the following words:

Its object shall be (1) to discuss new discoveries, to exchange experiences, and to carefully consider best methods of work; (2) to give opportunity to individual workers of announcing proposed investigations, so as to bring out suggestions and prevent unnecessary duplication of work; (3) to suggest, when possible, certain lines of investigation upon subjects of general interest; (4) to promote the science and advance the study of entomology.

The objects are well chosen and clearly and concisely stated. Let us consider them one by one.

We are "to discuss new discoveries." This implies, first of all, that new discoveries are to be made. It takes for granted that the members of this Association are to be scientific workers and not mere book students, content to thrash over old straw or to step exactly in the footprints of another. Each is expected, by his own careful research and study of nature, to add new facts to the sum of human knowledge. It is a noble aspiration for one to desire to leave as his legacy to the world some new idea or discovery to be of use to all succeeding generations.

Who could not "when his summons comes * * * wrap the drapery of his couch about him and lie down to pleasant dreams" if he could know he had brought such a blessing to his countrymen as the introduction of the Vedalia to the relief of disheartened fruit growers, or if he had made possible the successful culture of so valuable an article of food as the fig through the establishment of *Blatophaga grossorum* in American orchards, or if he were certain of having done anything during his lifetime of service that would be a sure and perpetual source of blessing to mankind?

You will recall that Dr. Fernald, in his presidential address, put the making of new discoveries first in importance in our work. In all science and in every industry it is the new discoveries that make further advance possible. They are the sure stepping-stones by which man ascends to greater heights and gets a broader view of the great world in which he labors. There are thousands to make use of a good thing when it has been discovered and made known to the world, but there is scarcely more than one in a thousand who can claim the distinction of really making a new discovery by which succeeding generations become his debtors.

Whether or not we have done all that might reasonably be expected of us in this regard I will not attempt to assert. I do believe we have lived up to this clause of our constitution as well as any. From infancy to old age, wherever a human being is found, it is as natural for him to announce to his fellows a discovery of something new to him in vision, in hearing, or in the realm of thought as it is for him to defend his person from an unfriendly blow or to take food when hungry. Galileo could no more refrain from telling the world that the earth moves than he could help breathing into his lungs the free air of heaven. Servetus, who first announced the continuous circulation of the blood, was not checked in the least in his determination to publish to the world what he believed he could demonstrate to be the truth, though he was fully warned of his probable fate.

All science is but a search after truth, and every fact established is a signboard for the guidance of all others that come that way.

It is no surprise, then, that many new discoveries have been made by the members of this Association, and that they have been promptly reported at these annual meetings or through station bulletins and entomological magazines.

The speaker believes it would be difficult to find so small a body of workers, with so meager an amount of time to be devoted to original research, in any other science, who can show larger results in the way of new discoveries in so short a time. So, while we endeavor to emphasize the importance of new discoveries, we believe there is reason to congratulate ourselves upon past achievements. Let these facts spur us on to greater endeavor, but let them not be to anyone a cause for resting upon his laurels.

How shall we proceed to the discovery of new facts? Is it sufficient to go about our duties with eyes wide open and minds alert, making discoveries at random here and there which have no close relation one to another? To make and chronicle any new discovery is well, but the difference between one who is simply a good observer and the scientific worker in applied entomology will be manifest in the fact that the latter will so plan and systematize his work that the facts observed and the conclusions reached will have an intimate relation one to the other and will form a basis for economic operations. While I believe the work in applied entomology is on a higher level in this respect than ever before, still there is room for improvement.

And then each should specially strive for those facts the possession of which will enable us to generalize and lay down working principles, or, as put by Professor Osborn in his address, "we should not neglect such underlying problems as shall perfect the fundamental knowledge of our science." One discovers that the male of a codling moth possesses a black stripe or dash on the underside of the fore wing which makes it possible to separate it from the other sex. It is a fact well worth recording and of importance to those who are working with the insect, but it has no underlying principle that enables one to draw important conclusions. To discover that the moth begins laying her eggs on the fruit about a week after the bloom has fallen; that the egg is about ten days in hatching; that the young larva usually enters the calyx of the fruit and there begins to eat into it; that the calyx of the apple closes within a few days after the petals fall, is to discover facts closely related to each other and which enable us to intelligently plan for the destruction of the insect.

In more than one presidential address we have been urged to put special stress upon life-history work. It is here particularly that we need new discoveries. Facts in life histories of insects must furnish a large proportion of the necessary basis for successful economic work. They are to the science of applied entomology what the laws of gravitation, of chemical affinity, and of the indestructibility of matter are to one who is to be an analytic chemist.

An examination of recent bulletins from experiment stations by the side of those that were published when this Association was organized will show that more and better life-history work is being done. Let us continue to improve in this important line of study and let us hear freely from all suggestions of new or better methods.

We should endeavor to choose those problems that are of peculiar interest, each in his particular State, or any important problem which others for some reason have shunned. Good examples of what I would urge are: The work being done by Professor Hopkins on the life histories of wood-boring beetles; the work of Dr. Forbes and others on insect diseases; the work of Professor Osborn upon the

Jassidae, and of Professor Slingerland with the codling moth. Many good examples have been set us in this work by Drs. Riley and Howard and their able staff of assistants. There is this difference, however, in the duties of the Government entomologist. He must see that all portions of the country have a share of his attention, for he is the servant of all, and the publications from his office indicate that he is doing well his duty in this regard.

In this connection I will pause long enough to say that it is not necessary to take for study some new pest that has never been introduced to the world. Much of the very best work in the investigation of life histories has been with the old pests that we were supposed to know perfectly. Since the work of Messrs. Washburn, Card, and Slingerland upon the codling moth we almost feel that we now have a new insect to talk about to the fruit growers in our respective States. A thorough study of almost any of the long-known pests would doubtless bring out valuable new discoveries in habits, and result in the employment of better means of prevention or remedy.

But we are not simply to make and report new discoveries; we are to "discuss" them when we meet on these occasions. These discussions are not alone for those who are to learn for the first time of the new discovery. If one knows that whatever he reports here will be closely criticised by those who are present, he will be more careful to make sure of his conclusions before communicating them to the public, and the standard of our work will be raised to a higher level.

So let us bear in mind the words of Dr. Fletcher in his presidential address in 1891, wherein he urged that we discuss all our experiences freely and in an informal manner at these meetings.

Here, again, we have followed in a commendable degree the letter of our constitution. But discussion may do good or harm, depending upon the manner in which it is given; and there have been occasions when criticisms were not wholly in the friendly spirit which ought always to characterize them. Let our discussions never have any unnecessary bitterness in them. An adverse criticism, at the best, is not a pleasant morsel. If it is needed, let it come, but let it always come as of necessity. Make a child feel that his chastisement is necessary, that he has brought it upon himself, and that the infliction of it is a duty and not a delight, and you will not incur his estrangement or hatred by giving it, and he will take a deep interest in seeing that there shall be no occasion for its repetition. The usefulness of our organization, as of any other, depends upon united efforts and a feeling of brotherhood among its members.

Next, it is our duty, according to our constitution, "to exchange experiences and carefully consider best methods of work." Experience meetings are not monopolized by religious associations. They are equally important to the success of all organized effort. No one

can be a toiler in any special line for a year without encountering experiences that might be related to a fellow-laborer to his profit. We are scattered over a large territory, having widely varying conditions of climate, altitude, and plant and insect life. Each can bring from his particular field some points of peculiar interest to all the others. While we may read one another's publications and perhaps exchange frequent letters until we almost feel acquainted, it is only occasionally that we can enjoy these meetings together, and it is a great inspiration to talk freely over one's experiences and plans of work face to face with those who are interested with him in similar lines of labor.

The student of applied entomology is supposed to have a good general knowledge of agricultural affairs, particularly in regard to plant growth. He must be informed upon all the insecticide materials and be able to tell what insects they are suited to kill, in what strength they may be applied to different plants, what their physiological effects will be on both plant and insect life, and when they can best be applied. He is supposed to be able to tell at a glance what any insect is that may be handed him, and whether or not it is injurious or beneficial. He is expected to be able to recommend the cheapest and best pumps or other machinery for the application of insecticides. Is it any wonder that we need to get together and exchange experiences and discuss methods of work, particularly when we remember that different results are obtained in different localities? Lime, salt, and sulphur, so valuable for the destruction of San Jose scale on the Pacific coast, was found to be of very little value in the moist atmosphere of the eastern portion of the country; the codling moth, said to have one brood in Maine, is reported to have two in Colorado, and three or four in other places; insects fairly common but never seriously abundant in one portion of the country are often found to be great pests in others. In view of these conditions it is important that we obtain all the ideas possible from fellow-laborers in different localities, that we may make as few mistakes as possible, and that we may not bring down upon ourselves the distrust of those whom we labor to benefit.

We are also "to consider best methods of work." Method is always important, and particularly is it to be sought for in a young science or industry where long experience has not yet determined the best plans of procedure. It was well at first that a large amount of individuality should enter into the work and a variety of methods be employed. Then, by a process of natural selection, the poorer methods would gradually drop out and the better ones be retained. It is time for this Association to lay aside its swaddling clothes and assume the garb of maturer years. It should be one of its objects to determine upon best methods as soon as expedient to do so. One recommends Paris green or London purple in the proportion of 1 pound to 200

gallons of water, while another will make it 1 pound to 160 or even 100 gallons for the destruction of the same insect. One recommends two sprayings for the codling moth, another three, and another says spray often enough to keep the fruit covered with a layer of the poison, so as to be sure of killing the second brood. Some advise hellebore for the pear slug, while others prefer one of the arsenites; and still another would use quicklime or simply road dust. Surely there is need of more method and uniformity in our work and in our recommendations for the control of particular insects. By free discussions at these meetings much can be accomplished to this end.

This consideration of "best methods of work" as well as the object expressed in the next clause, namely, "to give opportunity to individual workers of announcing proposed investigations, so as to bring out suggestions and prevent unnecessary duplication of work," brings upon us the importance of systematic cooperation in our investigations. Cooperation has been urged upon us at many of the meetings of this organization, but I do not see that much progress has been made in that direction. I am strongly impressed with the feeling that we are falling short of our possibilities by neglecting to cooperate more in our work. It may be best to hold to some very restricted line at first, and then experience will indicate other and broader methods.

Probably one of the chief difficulties of cooperative work is that each wishes to plan his own experiments and publish the results; then he does not have to share honors with another. Such a feeling is not altogether to be condemned. Neither is it necessary to so plan our cooperation as to make it essential to remove credit from him to whom it belongs. Let us suppose two entomologists are planning independently to test the effect of insecticides upon foliage. Each carries through his experiments and publishes the results of his labors. They are still independent experiments, the results of one not supporting or contradicting to any great extent the results of the other. Had each known what was being planned by the other, they could have arranged to carry out their experiments so that they would be largely duplications of each other, and when the results were published we should have double evidence upon the points under consideration where results agreed; and where they disagreed, we might be able to find in the different conditions the reason for it. Such a cooperation would bring results of far greater value than those obtained by independent experimentation, and neither party would lose any glory; in fact, each would receive more credit because of the better conclusions that could be drawn from the work. And then how carefully every conclusion would be reached and backed by positive proof for fear that the other party might get different results! Such duplication as this is of the utmost importance to establish scientific truth, and

the more we can have of it the better. It is only the "unnecessary duplication of work" that our constitution deprecates.

It is frequently the case that one is working out with considerable care the life habits of an insect, and a little information from exact observations upon some particular point in other localities would be of great service to him. The person giving the information would have full credit for what he did, and the world would have the benefit of the combined results. When time can not be taken by the head of a department for this aid, it may often be the case that a special student in entomology would be glad to get his name into a bulletin for doing a little good work. I have a case in mind to illustrate. The speaker is working on the life history of the codling moth. His observations make him wonder how it can be possible that there can be so few as one brood or so many as three or four anywhere. He would be greatly aided if a few entomologists in different parts of the country would make the following observations and report results this year. First, obtain date of blooming of the earliest apple trees. Second, determine the time of appearance of the first moths of the second brood by collecting a few of the earliest wormy apples and rearing the moths from them. Third, determine when the brood of worms that go over winter without pupation begin to leave the fruit. This can be done by placing cloth bands on the trees about July 15, and removing the larvæ that appear under them once a week until those have been taken that do not change to a chrysalis within a short time. Then, with the other facts that have been well worked out, it will be possible to state with considerable definiteness the number of broods in different portions of the country.

There is one other of the many opportunities for cooperation to which I wish briefly to call attention. So far as possible every station entomologist should build a collection representing the insect fauna of his State. In addition he should get together as complete a collection as possible of the injurious and beneficial insects of the whole country. The value of such a collection I do not need to urge upon you, as it will be admitted by all. I wish it might be determined by secret ballot in this meeting just how many out of a dozen of our worst pests that I might name are represented in the collections belonging to the different stations. I would not dare to ask you to reply verbally for fear it might be embarrassing. And then you might turn about and ask me to answer my own question. Don't any of you blush while you try to recall how many of the following species you can show to an inquiring friend: *Blissus leucopterus*, *Carpocapsa pomonella*, *Melanoplus spretus*, *Cecidomyia destructor*, *Coccotorus prunicida*, *Typhlocyba comex*, *Tinea pellionella*, *Cicada septendecim*, *Scolytus rugulosus*, *Psylla pyricola*, or even *Aspidiotus perniciosus* and *Aspidiotus ancyllus*. If you are fortunate enough to have the two last named, can you tell

them apart, or could you distinguish them if sent for determination? No reply is expected. Not one of these important species should be absent from any of our collections. By a little cooperative exchange we might all have them, along with many others.

The accumulation of the State fauna each must look after for his own region, but the general economic collection can be made only through some sort of cooperation. There are a large number of serious pests in rather restricted localities which should also be represented in all economic collections so far as possible. In Colorado the bean beetle (*Epilachna corrupta*) is as bad on the wax beans as is the potato beetle on potatoes; the fruit-tree leaf-roller (*Cacocia argyrosphila*) I have known to entirely defoliate whole orchards, and its close relative, the box-elder leaf-roller (*Cacocia semiferrana*), is equally destructive to the foliage of the box-elder; the currant and gooseberry fruit fly (*Epochra canadensis*) sometimes destroys three-quarters of the gooseberry crop, and the plum gouger (*Coccotorus prunicida*) punctures fully nine-tenths of our plums on the eastern slope, and still it would not be surprising to learn that in many of the States not one of these pests is represented in the station or agricultural-college collections. This does not seem right.

If the best way to build up our collection is by individual exchanges, then let us follow that plan. If we can adopt some general method and all work to it, let us do that. It seems to me this is a good problem for a committee to work out for us. In any case, let us all collect large series of duplicates of those insects that are specially injurious or beneficial in our different localities, and then endeavor by some plan to better our economic collections, and those of other States, through exchanges. I should be glad to hear of any who would like to have Colorado's injurious and beneficial insects in their collections and are willing to exchange species from other States for them. And then, it is often important to have the same species from different localities to note variations.

Let us talk freely of our plans, and let us hear suggestions from any and all in regard to methods and lines of investigation that seem to you to be specially important. In this way we shall broaden our horizon and get a larger view of the scope and importance of our work.

The next object as stated in our constitution is "to suggest when possible certain lines of investigation upon subjects of general interest." Such work would in large part be cooperative, but not entirely so. Nothing, perhaps, would be of more general interest than information and suggestions as to best methods of putting information upon applied entomology into the hands of the common reader. To what extent is it advisable to use the newspaper and the press bulletin? Is it best to put out bulletins in two series, one for the farmer and one for the station worker and specialist? Shall we publish all data from

which our conclusions are drawn, along with the bulletin to be sent to the general reader, or shall we publish in bulletins results only, and reserve tables and other exact data for publication in annual reports?

We are all interested to know to what extent the various horticultural inspection laws are efficient in the States passing them. What portions are specially valuable, and what portions do you consider of little or no use? Further laws are to be enacted the coming winter, and we want to know what to recommend in our various States in regard to them.

Lastly, we are "to promote the science and advance the study of entomology."

The usefulness of any applied science depends upon man's knowledge of the natural laws operating in that science. An astronomer could not determine the very day, hour, and minute when an eclipse of the sun would be visible at a particular spot on the earth's surface, or the exact date of the return of a comet, if he did not thoroughly understand the operation of the laws by which these marvelous phenomena are brought about. Neither can applied entomology accomplish its highest mission in the world for man's benefit until he succeeds in thoroughly working out and interpreting aright the laws which prevail in the insect world, and they are many and intricate, and some of them difficult of solution. Whatever we can do to interest others in the study of insect life in any of its phases, to the end that new facts are recorded, will help to the more perfect understanding of our favorite science and consequently to its usefulness. We are greatly indebted to the pure systematist in entomology who never attempts to make a practical application of his knowledge.

It would greatly promote the science of entomology if each member of this Association would make a special systematic study of some group of insects, however small, and publish the results as a personal contribution to the pure science of entomology. We would be better workers in economic problems for so doing. A study of the habits of insects in nature's laboratory fits one for a grade of systematic work that he never could attain as a closet naturalist.

A knowledge of food plants, of broods, of local variations, and of variations occurring among the offspring of a single pair, determined by careful observation in nature's haunts or by breeding in the laboratory, is as essential to enable one to establish true specific differences as is a thorough knowledge of structural character.

To promote a science it is necessary to make known its relations to human interests. If men can be shown that their health, wealth, or happiness depends upon a knowledge of insect life, there will be no trouble to interest people in the study of entomology. Show the farmer, the gardener, and the horticulturist the importance of knowing the habits of insects in order to successfully combat the pests that

destroy their crops; bring to the attention of the preacher the inexhaustible fund of evidence and illustration with which to teach his flock the power, wisdom, mercy, care, and omnipresence of the Creator of all; make known to the artist the boundless field which a study of insects opens to him for the display and development of his powers in portraying graceful and fantastic forms and in preparing and blending colors of the most exquisite beauty and harmony; teach those who instruct the young what a wealth of interesting and easily obtained objects are always at hand from insect life with which to fascinate the child and secure his lifelong interest in natural history study; make it plain to all that the very laws of life that prevail in the higher realm are equally patent among the creeping, crawling creatures of lower rank and smaller size--do all this, and the science of entomology will quickly take the rank it deserves among its sister sciences.

In closing let me urge that we keep in mind the worthy objects for the promotion of which we are banded together. Let us keep the standard of work up to the ideal conceived by those in whose minds the organization had its birth. Let us show a willingness to sacrifice self-interest when it is necessary for the general good, and let us do all in our power to preserve and strengthen the fraternal feeling that has ever existed among our members.

Mr. Weed moved a vote of thanks to Mr. Gillette for his interesting and suggestive address, the motion being seconded by Mr. Johnson and carried unanimously.

Before leaving the chair, Mr. Howard called attention to the fact that it had been the custom to postpone discussion of the presidential address until the afternoon session, in order to have a short time for the transaction of business.

Reports of the secretary and the treasurer were read and, on motion of Mr. Webster, were accepted.

Mr. Howard moved that a committee of three, to include the chairman and the secretary, be appointed to prepare a programme for the rest of the meeting.

Mr. Johnson suggested that, in view of the fact that the Association was to join with the Society for the Promotion of Agricultural Science on the following day, the committee of three be instructed to consider that programme also.

The motion was adopted and a committee consisting of the chairman (Mr. Gillette), the secretary (Mr. Kirkland), and Mr. Weed was appointed and requested to meet immediately on adjournment.

Mr. Howard moved that the secretary place on the list of members the names of Frank Benton, Richard S. Clifton, and August Busek, all of Washington, D. C.

Mr. Hopkins proposed the name of Trevor Kincaid, of Seattle, Wash.

Mr. Webster proposed the name of Wilmon Newell, of Wooster, Ohio.

Mr. Woodworth proposed the name of Carroll Fowler, of Berkeley, Cal.

Mr. Fernald proposed the name of C. M. Walker, of Amherst, Mass.

Mr. Howard moved that a committee on officers for the next meeting and also a committee of three on resolutions be appointed to report on the following afternoon.

The motion was carried and the chairman announced that the committees would be appointed later.

Mr. Howard then presented a paper on:

PRESENT CONDITION OF THE BLASTOPHAGA IN CALIFORNIA.

By L. O. HOWARD, *Washington, D. C.*

In this paper the speaker detailed the operations in the introduction and establishment of *Blastophaga* which had been carried on since the last meeting of the Association. As a fuller and later account will be published in the Yearbook of the U. S. Department of Agriculture for 1900 the paper presented is not published here.

ESTABLISHMENT OF A NEW BENEFICIAL INSECT IN CALIFORNIA.

By L. O. HOWARD.

[Abstract.]

A second note presented by Mr. Howard also related to the introduction of a beneficial insect. He stated that it would perhaps be remembered that at the tenth annual meeting of this Association he had referred to his efforts to introduce and establish in this country, with the assistance of Prof. Antonio Berlese, of Italy, the interesting Oriental parasite known as *Scutellista cyanea* (see Bulletin 17, n. s. Div. Entom., U. S. Dept. Agric., pp. 13, 14.) In Italy this curious parasite occurs commonly in the wax scale (*Ceroplastes rusci*), and it was introduced into Italy in all probability from the Orient about forty years ago, although originally described by Motschulsky in 1859 from specimens reared by Nietner in Ceylon from *Lecanium coffee*. The living specimens were sent by Dr. Berlese and his colleague, Dr. Leonardi, and were colonized at Baton Rouge, La., through the courtesy of Prof. H. A. Morgan and Prof. S. E. McClendon; also in Washington, D. C., in the insectary of the Division of Entomology upon *Ceroplastes cirripediformis*. The Washington specimens did not

succeed in perpetuating the species and nothing has been found since of the Louisiana material. A year later Mr. C. P. Lounsbury, government entomologist of Cape Colony, found this species parasitic upon *Lecanium oleæ*, the common black scale, in Cape Colony, and sent specimens to the writer for identification. The past spring, Mr. Lounsbury, at the writer's request, made formally through the United States Secretary of Agriculture to the Secretary of Agriculture of Cape Colony, brought with him from Cape Town to New York two boxes of twigs covered with the black scale affected with this parasite, and expressed them to Washington, whence they were immediately forwarded to Mr. E. M. Ehrhorn, the horticultural inspector of Santa Clara County, Cal. On June 19 the writer received a letter from Mr. Ehrhorn announcing the arrival in living and healthy condition of the parasites in question. The twigs in one box were somewhat moldy but quite a number of parasites were crawling about in the box and were found in the pupal condition in some of the scales. Mr. Ehrhorn had been warned by telegraph and had prepared twenty-five infested oleander plants by potting them and had covered each with a tight bag of the finest Swiss muslin. In these most of the parasites were liberated and a few were allowed to fly in the orchard. Specimens of a hyperparasite (*Tetrastichus* sp.) also survived the journey, but Mr. Ehrhorn was on the lookout for this parasite and isolated them as they appeared, pending instructions from Washington as to their destruction. The writer had strong hope of the successful establishment of this species at San Jose, the climate being appropriate and the supply of food unlimited, and stated further that this was another instance of international entomological work which emphasized the fact that this Association through this class of work binds together its members all over the world more than any other association.

BENEFICIAL WORK OF HYPERASPIS SIGNATA.

By L. O. HOWARD.

[Abstract.]

In a third note presented by Mr. Howard he stated that at the meeting of this association held in 1898 he had the pleasure of calling attention of the members to the rehabilitation of *Pulvinaria acericola* Walsh and Riley, a *Pulvinaria* which occurs upon the leaves of maple. The full life history of this species and also of that of *Pulvinaria innumerabilis* were displayed in Bulletin 22, n. s., of the Division of Entomology, U. S. Department of Agriculture. Under the head of natural enemies of both species the little ladybird beetle, *Hyperaspis signata*, was especially mentioned and the statement was made that it was received in the larval state from Knoxville, Tenn., feeding upon

the scale. On June 18 of the present year an additional lot of specimens upon maple leaves was received from Prof. Hunter Nicholson, of Knoxville, Tenn., and with them numbers of the larvæ of the *Hyperaspis* feeding energetically upon the eggs of the scale insect. Drawings were made of this very peculiar and characteristic larva which are reproduced herewith. The striking likeness of the larvæ of the *Hyperaspis* to a mealy bug will at once be noticed. Were it feeding upon mealy bugs instead of upon *Pulvinarias* (and it frequently does feed upon mealy bugs) it would at once be evident that



FIG. 1.—*Hyperaspis signata*: Larvæ feeding upon *Pulvinaria* on leaf of maple above, natural size; below, enlarged (original).

we have here a clear case of what Professor Poulton calls "aggressive mimicry."

Mr. Gillette expressed the wish that the Association might have more talks like Dr. Howard's, and asked if there were any questions or suggestions.

Mr. Howard said he would be glad to hear from Mr. Lounsbury on the subject of the parasite of the black scale. He said he wished to add that Mr. Lounsbury had sent two boxes—one a deep box and one a shallow box. The shallow box carried the more successfully. The scales had begun to rot in the deep box.

Mr. Lounsbury replied that he was more in quest of information than anxious to give it, and would like to know if anything had been done about the secondary parasites.

Mr. Howard stated that a number of secondary parasites of the genus *Tetrastichus* had issued, but Mr. Ehrhorn was forewarned and isolated them as fast as they emerged, so there was no danger.

Mr. Lounsbury stated that the history of the case dated back to his first arrival in Cape Colony. Before he had been there a year he noticed that the black scale was not injurious, and upon traveling about the Colony he found the same condition true over many thousand miles of territory. Later, upon obtaining specimens of the parasite and corresponding with Mr. Howard on the subject, the latter had suggested his sending it to California. For four years he had been watching for an opportunity to get a sufficient number of parasites to send, but the scale is so well kept in check by the parasites or by other factors that until this year he was unable to find a large quantity. Last year he mentioned the matter in his annual report, a copy of which he had sent to Mr. Ehrhorn, who at once wrote and asked him to take steps to get the parasite established in California. He replied that he would gladly do all he could, but would like Mr. Ehrhorn to make it a formal matter so that he might be able to spend the time and money necessary. This was done and Mr. Lounsbury received formal orders to go ahead. He set about in two ways: First, he had scales collected and reared young larvæ from them, which were placed on young oleander trees now being kept in the Cape Town gardens. Primary parasites were to be admitted to the plants, but secondaries excluded. These plants in time he may be able to send to the United States in Wardian cases. Second, while waiting for these to develop he had Mr. Mally go out and search the country side, with the fortunate result that relatively large colonies of scale were found where Mr. Lounsbury had seen small colonies the year before. Mr. Mally collected for nearly a week and brought in over a bushel of twigs which were carefully sorted, cut into foot lengths, and the ends dipped into sealing wax. The twigs were then wrapped in tissue paper. The matter of the differently shaped boxes was purely accidental. He went to the grocery shop and picked out what he thought would be best suited, taking one shallow box and one deep box in order to try them. He thought that packed in the manner above described and placed in a wooden box what moisture came would be absorbed by the wood. The boxes were packed the night preceding Mr. Lounsbury's departure, the deep box being placed on a dry shelf in the fruit room of the Cape steamer and the shallow box kept in his stateroom. In this way the insects were taken to England, which he hurried across and took the next liner. He then tried to get the box which he had kept in the fruit room also placed in a cool room on the New York steamer, but found no choice between putting it in the meat room or leaving it outside. He preferred not to freeze the insects because the parasites not being accustomed to such temperature might succumb, and he therefore placed

the box in an empty cabin below the water line. The voyage was fortunately cool, the temperature averaging about 60°. The shallow box was kept in his stateroom, as on the Cape steamer, and immediately upon arrival at New York both boxes were shipped to Mr. Howard. They arrived in New York in twenty-five days from Cape Town, a quick passage which, perhaps, could not be repeated. Mr. Lounsbury further stated that on first writing to Mr. Ehrhorn the latter took the letters to Mr. Leib, a fruit grower, and Mr. Leib in some way put the matter in operation. Mr. Lounsbury wrote to Mr. Leib and said he would try to make a success of the matter, and advised him to get oleander plants and infest them with black scales and have things so arranged that he could put the plants under cover. He suggested further to Mr. Leib that if he should receive a sending of parasites on cut twigs the boxes should be opened in a closed room so as to allow the parasites to fly to the windows. This was the only way that occurred to Mr. Lounsbury for the removal of the secondary parasites. The primaries were to be collected and then liberated with the scale-stocked oleanders. As regards the oleander plants to come later, he had planned to prevent secondary parasitism, which he thought would be better if it could be carried out.

Mr. Lounsbury asked if there had been much experience to show the best method of sending parasites, and if it would be well to freeze them? He knew before he left Cape Town that the parasites in question would keep emerging for a month in closed jars in his office.

Mr. Howard replied that he did not think we could say yet what is the best way. One thing is certain, however, and that is that tin boxes should never be used in sending from the Tropics.

Mr. Gillette asked if it is quite certain that the *Blastophaga* is only three brooded in its native home.

Mr. Howard replied that they have lost track of the insect in its native home during a period of about two months and there is a possibility that there may be in certain places in Mediterranean regions a fall brood. The condition of their knowledge over there is more or less incomplete.

Mr. Johnson asked if the black scale in South Africa is destructive to citrus trees to the same extent as in California.

Mr. Lounsbury stated that he had seen citrus trees infested in only about ten places in the last five years in South Africa, and never more than a few scales at any of these places. Occasionally he had seen the scale on citrus trees from Natal or from Australia which had been imported to the Cape. One orchardist having several thousand trees said he had seen a little on his Australian trees, but it had disappeared. Mr. Lounsbury was unable to find any there after a year from the importation.

Mr. Fletcher asked of what country the scale is a native.

Mr. Lounsbury replied that he did not think it is known. The scale must have been in Cape Colony for many years and is not confined to citrus trees. It occurs most commonly on oleander and myroporum. He had found it 150 miles inland and on numerous indigenous plants away from settlements.

Mr. Johnson asked whether the parasite is solely responsible for the reduction of the scale in the orchards, and whether oleander is grown in South Africa as it is here, under glass.

Mr. Lounsbury replied that oleander at the Cape is an outdoor plant. He could not say positively that the scale is held in check solely by the parasite. It comes and goes, and is never very abundant. Only twice has he been shown by a farmer the scale on citrus trees.

Mr. Johnson, referring to Mr. Howard's description of the covering of fig trees much in the same way that *Vedalia* was covered in order to keep the figs on the trees, asked if it is necessary for the fig to remain upon the tree in order that the parasites may be carried through the winter with it.

Mr. Howard said that he assumed so.

Mr. Johnson suggested, from what he had seen of the condition in which the fig winters, that it might be possible to take figs at certain times from the trees and thus keep the insect through the winter. If this could be done it would do away with the outdoor covering. Whether or not the figs could be kept through the winter under certain conditions is well worthy of trial. While on this topic of parasites he desired to state that he had recently received a communication from Mr. Ehrhorn, in which the latter asked for parasites preying in the East on the imported cabbage worm. It seemed to Mr. Johnson that this was a matter for cooperation, and he merely mentioned the fact as a suggestion from Mr. Ehrhorn that it is very desirable to establish such parasites in that section. He had promised to do what he could from his end of the line, and he hoped that others who were fortunate enough to possess such parasites would also assist. He had also received a request from Professor Morgan for specimens of the parasite which he had bred and which Mr. Howard had named. Professor Morgan is anxious to colonize this parasite on *Murgantia histrionica* in Louisiana, and Mr. Johnson had promised to send him parasitized eggs of the harlequin cabbage bug at the earliest opportunity, but up to the present time had been unable to find any specimens of this destructive pest. Three years ago it was one of the most destructive insects in the Maryland and Virginia cabbage-growing sections, but since the freeze of February, 1899, he had seen very few specimens. He was unable to say whether this was due entirely to the freeze or to the parasites. The parasite is a new species (*Encyrtus johnsoni* Howard, Can. Ent., Vol. XXX, pp. 17, 18) and there seems to be some promise of its successful introduction into the South.

Mr. Gillette said he considered the matter of parasites one of great interest, and he hoped the subject would be further discussed. In Colorado nature often seemed out of balance. There are a number of species which are not abundant in the East, but which are very injurious in Colorado, and he thought it was because the parasites have not been carried to that section of the country. In his opinion it would be of the greatest benefit to certain portions of the country to introduce insect enemies, both parasitic and predaceous.

Mr. Howard said he desired to call the attention of the members of the Association to the fact that this was the most representative meeting of the Association ever held. Not only was Mr. Woodworth, of California, present, with Mr. Fernald, of Massachusetts, Mr. Weed, of New Hampshire, and Messrs. Quaintance and Scott, of the Southern States, but also "our dear old friend," Mr. Fletcher, of Canada, and Mr. Lounsbury, who had carried American economic entomology clear across the Atlantic Ocean to South Africa. Mr. Currie, the under secretary of agriculture for Cape Colony, who was recently visiting Mr. Howard in Washington, had said that he was very glad indeed that he had sent for an American entomologist to come to the Cape, and congratulated his department upon being able to secure such a man as Mr. Lounsbury. Mr. Howard further stated that while on this discussion of scale insects it was well to call attention to the fact that there was present in the room the man who first started the study of scale insects in this country—Professor Comstock, of Cornell University—and he suggested that Professor Comstock be called upon to say a few words.

Mr. Comstock stated that his knowledge of scale insects was a matter of ancient history. It was fifteen years since he had been drawn away from their study by other duties. Now when scale insects are sent to him, as they are very often, he sends them to Mr. Howard. He was very glad to meet with the Association, but regretted that he was in bad health and probably would not be able to remain through the sessions. So, if he was not present at the meetings it was not because his heart was not with the Association.

Mr. Felt then presented the following paper:

SOME EFFECTS OF EARLY SPRING APPLICATIONS OF INSECTICIDES ON FRUIT TREES.

By E. P. FELT, *Albany, N. Y.*

We have heard considerable in recent months about the value of crude petroleum as an insecticide, and one entomologist has stated, in giving his conclusions regarding its effects on fruit trees, that this substance "is harmless to the most tender varieties and on the youngest trees." There is no doubt but that crude petroleum possesses valuable properties, but in the light of results obtained in the

vicinity of Albany, N. Y., the assertion quoted is too sweeping in its character.

This spring a series of tests were begun with the avowed purpose of learning the best method of controlling the San Jose scale in orchards. During the progress of this work trees were treated with mechanical mixtures of water and kerosene and with crude petroleum in a similar manner, using 20 and 25 per cent of the oils, which were applied with a Gould's kero-water sprayer. A few trees were treated with undiluted kerosene and others with undiluted crude petroleum. A number of trees were treated with whale-oil soaps. Leggett's Anchor brand and Good's caustic potash whale-oil soap No. 3 were each used at the rate of $2\frac{1}{2}$ pounds to a gallon of water. A combination of whale-oil soap and crude petroleum was also used on a number of trees, the proportions being 1 pound of the soap to 4 gallons of water and to 10 gallons of the soap solution 1 gallon of crude petroleum. A kero-water sprayer was on the ground and it was therefore easier to prepare the soap solution and arrange the apparatus to deliver 10 per cent of crude petroleum. This produced an emulsion as it passed through the nozzle. In addition to these, 12 trees were treated with hydrocyanic acid gas, using from 1 pound of the cyanide to 75 cubic feet to 1 pound to 150 cubic feet of space. The spraying was mostly done on April 11, though the fumigation was delayed until the 19th to 21st of April, at which time the buds had started some. This work was performed in a mixed orchard of over 100 young pear, peach, plum, and cherry trees, where the San Jose scale had been for about eight years, and the trees presented, therefore, every degree of infestation. Unfortunately, it was necessary to confine the use of the undiluted kerosene and crude petroleum to the worst infested trees. It is yet early to pass upon the effectiveness of these substances as insecticides and, therefore, only the effects on the trees will be considered at this time.

The spraying with the insecticides occurred just before the buds began to open, and with the exception of the trees treated with undiluted kerosene or crude petroleum very few or no harmful effects were observed. Examination of the experimental orchard eight days after spraying, showed that as a rule the trees were budding out. Those treated with kerosene gave little indication of the presence of the oil on the bark, while the dark color of those treated with crude petroleum was very apparent, a condition which persisted till June 20 at least. The whale-oil soaps showed to a considerable extent, the bark of the trees treated with Good's being moist, while many of those sprayed with Leggett's showed a white incrustation. The harmlessness of a mechanical 20 per cent kerosene emulsion applied at this time is well shown in the cherry tree No. 3, photographed May 12 while in full bloom. Tree 15, a Seckel pear, photographed May 14, shows well the harmlessness of a mechanical 20 per cent crude petro-

leum emulsion. Similar photographs could be shown in the case of 25 per cent mechanical emulsions of both kerosene and crude petroleum. But when we come to examine the results obtained with the undiluted oils, even after making allowance for scale injury, one can not resist the conclusion that both kerosene and crude petroleum may cause serious harm. Pure kerosene was considered by the owner of the orchard as dangerous material to use on a tree, and on that account but three trees were sprayed with it and all of them were in very bad condition from scale attack. The Howell pear tree No. 21 was sprayed April 11, photographed May 14, and was quite badly infested with the scale. At this latter date most of the tips of the limbs showed few leaves, and there were very few blossoms. The tree had evidently suffered considerably from the scale, and it is probable that the kerosene also injured it. June 20 the foliage of this tree had developed considerably, and while there were a number of dead branches, the suckers thrown out may eventually fill the vacant places.

It is with the crude petroleum, however, that the most marked results were obtained. The seckel pear, No. 101, was photographed May 12 and shows well the very few undersized, pale leaves. June 20 there were only a few bunches of leaves on four limbs, and a number of adventitious buds were developing. The foliage at this time was light in color. This tree was badly infested with San Jose scale, but, making due allowance for that, it is still far from what it should be. The Lombard plum tree, No. 93, was photographed May 12 and shows very well the effects of a spring application of crude petroleum. This tree was but moderately infested with the scale, and consequently most of the injury can be charged to the treatment. Only the stronger buds near the tips of the branches stood the test well. Many of those on the side branches were killed and others much weakened. The 28th of May I made the following note concerning this tree: "Leaves out considerably, but the foliage is still much thinner than on other trees of its kind." June 20 it was still seen that the foliage was thinner than the normal. The next tree, a Botan plum, was apparently in the same condition as No. 93 at the time of spraying, but on May 28 there was just one weak leaf, and a few of the apparently dead twigs showed a little green beneath the bark. Later the owner dug the tree out as dead.

Applications by horticulturists or farmers are worthy of close attention, because they are made more nearly under usual conditions. I was therefore very glad to avail myself of the opportunity of watching closely the results obtained by one. The extensive and abundant infestation of his young orchard with the San Jose scale led Mr. L. L. Morrell, of Kinderhook, N. Y., to try crude petroleum. Some young tree tops worked with Sutton Beauty were sprayed April 1 with 25 per cent mechanical mixture of crude petroleum, the trunks having been

previously painted with the oil. The grafts were 2 or 3 feet long, and had undoubtedly been severely injured by the oil. The lateral buds were dead in many cases and the foliage looked weak and sickly May 21. Since then portions of these trees have died. The killing of lateral buds was also noticed by Mr. Morrell on other trees sprayed with about this proportion of crude petroleum. The foliage was very thin, many of the lateral buds were killed, and the leaves were small and unhealthy. Writing June 20, Mr. Morrell states that with very few exceptions the trees painted with crude petroleum in the middle of February are looking well, some having some fine fruit on them. The most striking result was seen in three King trees painted by this gentleman with crude petroleum December 1, 1899. One of these King trees was photographed May 21, and was then nearly dead. June 20 Mr. Morrell stated that these trees are dead so far as one can see.

These facts show that crude petroleum may seriously injure trees under certain conditions. The trees may eventually outgrow the harm, and it is possible that the injury would be no greater than the scale would cause if allowed to go unchecked. The foregoing shows that the injury to the tree is less the later in the spring the application is made, provided the buds have not opened. The mechanical dilutions of crude petroleum, at least up to 25 per cent, appear to be harmless if applied before the buds open, and it is hoped that they will prove effective in controlling the scale.

A general discussion followed the reading of Mr. Felt's paper.

Mr. Gillette considered the subject one of great importance. In Colorado a number of people had sprayed in the early spring with crude petroleum because of the recommendations seen in newspapers. He asked if others present had tried crude petroleum, and if so, with what results.

Mr. Scott said that in Georgia he had carried out experiments along this line in February and March on peach and plum trees, about 3 barrels of crude petroleum purchased from the Standard Oil Company being used, at from 20 per cent up to the pure oil. He found that pure crude petroleum killed peaches and plums outright.

Mr. Felt asked when the oil was applied.

Mr. Scott stated just before the fruit buds opened in the spring. Fifty per cent and less strength did very little damage, but the best results were obtained with 25 per cent in mechanical mixture with water sprayed with a Gould kero-water sprayer. He also used 30 per cent, which did no damage to the trees and was quite effective in destroying the scale, but a mixture stronger than 25 per cent seemed unnecessary, as all the insects reached by the spray were killed accord-

ing to notes made up to June 12. Until that date the sprayed trees remained oily and the odor of the crude petroleum could yet be detected. It is a reasonable conclusion, then, that the scale can not live so long under such a coating of oil. He had concluded that the 25 per cent crude petroleum in mechanical mixture was better than refined kerosene of the same strength.

Mr. Woodworth said that when the bulletin from the New Jersey Station came out it was heralded all over California, and he had to write more letters in regard to the kerosene and crude-petroleum treatment than about any other insecticide. Crude petroleum in California is a very indefinite term, since there is a crude petroleum from Ventura which is as thick and black as molasses, and from that it varies to crude petroleum which is almost as thin as gasoline. Even in a single well the product varies according to depth and age, and distillations show that it varies greatly in composition. He had been assured that the Eastern product varied also, and was of opinion that before we can recommend any percentages of crude petroleum we will have to establish a criterion of excellence. The different kinds of crude petroleum he had experimented with in California produced very different results—strikingly different. There is also a very decided difference in results according to time of spraying with the same oil. Thus spraying before rain and after rain may produce entirely different results. He had sprayed with some forms of crude petroleum without injury which would have thoroughly destroyed the foliage at another time of day. The amount of water in the leaf may determine to a certain extent the damage by the oil. It seemed to him, therefore, that another thing that must be done before we can really properly understand the action of the oil will be to study the effect of the oil upon the vegetable tissue. Perhaps this had already been done, but it was still in large part a mystery to him.

Mr. Webster said he had used oil from two wells located in different parts of Ohio this year, and although the analysis ran almost exactly the same in each case the effect has been different. In the one case he had not seen the orchard for several weeks, but when he last saw it the peach trees seemed to have been in many instances killed by the use of crude petroleum. He could not say whether the oil had been applied just before or just after a rain. In the other case the trees sprayed were seedling apples on the experiment farm, the experiment being made to determine if possible the effect upon the trees and not against insects. Some of the trees leaved out at the proper time about as freely as usual, while others had no leaves at all. At the present time, however, there was no apparent difference whatever in them, all having finally leaved out precisely the same. It was evidently nothing but a temporary injury. His experiments had produced such varied results that he was badly mixed up and did not favor

recommending the use of kerosene of any sort. He was of the opinion that the variation would be just as great in the crude article as in the refined.

Mr. Hopkins said that in West Virginia they have a great variety of petroleum, from that as thick and black as molasses to the thin light-colored product. The oil obtained from the Standard Oil Company is a mixture of all kinds except the heavy oil. The heavy oil is used for lubricating machinery. He had obtained some results which are quite at variance with the testimony of others and shows what conflicting results can be obtained in different States. In one case he recommended crude petroleum as an experiment in a large orchard which was almost dead from the scale and which the owner refused to cut down. It had been sprayed once with pure kerosene, which did some damage and killed many scales, but the owner had allowed it to go without treatment and the scales had again covered the trees. He sprayed it with crude petroleum obtained in Baltimore. When he last saw the orchard, in April, the trees were black and greasy, but underneath the bark they were as healthy as ever, the leaves were coming out in full, and the owner claimed that the crude petroleum had benefited them. He was not recommending the oil, but simply giving this as an example. His spraying was done in February and wherever the oil touched the bark it remained dark and greasy for months afterwards. A thorough examination failed to reveal any of the living scales, and he believed that the young scales could not settle and live on the oily surface. He felt very much encouraged. It is one of those problems which require cooperative work. As a result of further investigation, he thinks it may become one of the best insecticides ever discovered. He could not think of any better work than trying to find the reasons for the great difference in results in experimental work with insecticides.

Mr. Webster said he was unable to see what could be gained even if crude petroleum should be perfected. It was true that we will have to get something cheaper and more effective than whale-oil soap, which if used on peach trees except during the winter will destroy the fruit, but in view of the difficulty he had had in getting crude petroleum and the high price asked for it, how much better an insecticide than whale-oil soap would we have even if it was perfected? He thought that entomologists who cared for their reputation would experiment much and say little for publication, for the present at least. He further stated that while experimentation was always in order, it would be best to stick to the whale-oil soap until more obscurities in regard to the use of petroleum had been eliminated.

Mr. Johnson said he agreed with Mr. Webster. We have got to get something better than kerosene for both peach and plum. In one instance he had sprayed an orchard of two hundred 9-year old peach

trees in February with 25 per cent kerosene and not a tree was living on the 28th of April last. He was at present making midsummer experiments. It seemed to him that atmospheric conditions were at the bottom of the difficulty and he thought it would be necessary to go back to the old whale-oil-soap remedy which destroyed the scale more effectively and was less liable to injure the trees. It would not be wise to substitute crude petroleum for whale-oil soap. After three years experience with kerosene, whale-oil soap, and gas he was of the opinion that there are other conditions which must be studied more seriously in the future than in the past, and he heartily agreed in the opinion of the chairman that cooperation is desirable. He believed it would produce better results in the future. We must not confine our labors to the territorial boundaries of a State but go outside for information, suggestions, and the experience of others.

Mr. Fletcher stated that he was glad to hear what had been said about whale-oil soap and crude petroleum. He had never yet been able to see what object there was in trying to use petroleum. The results were too conflicting and always unsatisfactory, and the question of cost in the destruction of the apparatus was never considered. There was very slight injury to the hose in the use of potash whale-oil soaps, which could now be obtained of pretty uniform manufacture, and had been giving good results. These are always to be had and easy to get to most places. You can be sure of getting your whale-oil soap within a week or ten days, while he had found there was considerable difficulty in getting crude petroleum. He was of the opinion that there is room for experiment with much weaker mixtures of the potash soaps during the summer. His experience had been in favor of the potash soaps in preference to the crude petroleum or kerosene mixed with water. Even with the old kerosene emulsion there is sometimes unexpected injury to trees, which was always put down to difference in the oil or in the water. He was satisfied for the present that the whale-oil soap was the safest remedy; at any rate, it is the safest for those who are official entomologists, and have to recommend formulae to people who will make a mistake if they possibly can.

Mr. Sanderson stated that he had not had much experience with crude petroleum, but so far his experience has been favorable. He sprayed an orchard of one hundred trees on the Delaware River with crude petroleum in the latter part of January, on a cloudy day, with a little hail and rain soon afterwards. The trees were mainly Bartlett, Kieffer, and Manning pears, which had been sprayed the year before with pure kerosene and somewhat injured, but which had recovered. Two months later, in March, he sprayed another lot of one hundred trees with 25 per cent solution of crude petroleum. It was a very windy day, and almost all the trees previously sprayed got a dose of the 25 per cent solution on one side. Examination shows no injury on either lot.

Here and there could be seen a tree not doing well, but that was owing to the spray of a year before with pure kerosene. The buds were not injured. The growers in his region never use whale-oil soap, because it destroys the buds. They have used it during midwinter and destroyed buds, and have now given it up.

Mr. Woodworth said that he did not wish his former remarks to be construed to mean that there is no future for crude petroleum as an insecticide, but he desired to emphasize the fact that there is a great deal to learn. In some of the large orchards in California crude petroleum has been used with success, but not against the San Jose scale. He is of the opinion that there is a great future for crude petroleum, and that the time will come when it will be cheaper in the East. In California it is the cheapest insecticide that can be bought.

Mr. Hopkins said that in his State (West Virginia) crude petroleum was sold to the Standard Oil Company for about 3 cents per gallon, or \$1.25 to \$1.50 per barrel, and if there was sufficient demand for it for a specific purpose he thought there was no question but that the cost would be reduced much below that of whale-oil soap.

The chairman appointed the following committees:

Committee on nomination of officers for ensuing year: Messrs. Fletcher, Howard, and Woodworth. Committee on resolutions: Messrs. Felt, Johnson, and Burgess.

The morning session then adjourned: the afternoon session to begin at 2.30 p. m.

AFTERNOON SESSION, JUNE 21, 1900.

On motion of Mr. Webster all discussions were limited to five minutes each, no person to speak more than twice on the same subject.

Mr. Webster moved that the secretary place on the list of foreign members the names of

Gustavo Leonardi, of Portici, Italy.

Robert Newstead, of Chester, England.

Karl Sajo, of Budapest, Hungary.

Mr. Howard proposed the name of Edmond Bordage, of St. Denis, Réunion.

In discussing the annual address delivered by Vice-President Gillette, Mr. Weed said he thought, as did all the other members, that there were very many excellent ideas in the address. One of the most important ones was that about active cooperative work and the sending of parasites back and forth. If close track was kept of some of the great crop pests in this respect, watching carefully the parasitism, entomologists in different States could do each other a great deal of good.

Mr. Webster thought there were a great many good features in the address and very many of vital importance to station entomologists.

It seemed to him that the fact that this international and interstate matter was made a prominent feature was a very good indication of progress, something that was hardly anticipated when the Association was established. There were so many good points in the address that it was absolutely impossible to do justice to it in a few minutes. Some things, however, he considered entitled to especial emphasis, and one was the matter of duplication of work. The fact that one member was working upon a given species in one State and another member working upon exactly the same species in another State, while apparently a duplication of work, is not, in fact, a duplication at all, because in all probability very different results would be obtained. No two men see the same thing in the same light, and climate, latitude, and elevation also have a great deal to do with the actions of insects. As to the matter of mapping out work, it must be remembered that most entomologists are limited in their powers, and, while they can plan work, it is not always easy to carry it out, as a station director or a board of trustees might greatly revise his plans. In regard to the introduction of foreign parasites, it seemed to him that it is a field we are just entering, with the future all before us, and there would be many failures; but where such work was carried out carefully he believed it might prove successful with respect to a great many introduced species of insects. When we come to carry it out between States, however, other difficulties will surround us. He went to a great deal of pains to obtain from Professor Morgan an egg parasite of *Murgantia*, and after getting it established it was swept out of existence during the winter of 1898-99, and no good has come from the introduction. He was also of the opinion that a great deal could be done by an exchange of experiences with insecticides, such as had taken place in the morning session, as insecticides seldom have the same effect in different portions of the country. It had always seemed to him that the work of the economic entomologist was very largely to work out life histories, and after he had done this and had found out methods that could be used to destroy the insect his duty ends and the work of the horticulturist and the agriculturist begins. He did not think it ought to be necessary for an entomologist to make of himself a mechanical, hydraulic, or civil engineer.

Mr. Fernald referred to the remark just made by Mr. Webster to the effect that no two men saw the same thing in the same light, and said that the same was often true in listening to an address, for generally no two men got the same ideas from it. For him other parts of the address than those mentioned by other speakers had presented themselves with particular force, and especially those with reference to collections in connection with the insectary or entomological work of any kind. It seemed to him that the work of a station, whether connected with a college or not, is most emphatically educational, for

even if it be not educational to students or visitors, it is certainly educational to the workers at the station themselves, and by continually adding to such a collection they are adding to their education as well as to the education of the residents of the region. He had thus far found a great demand for collections rather different from those ordinarily met with. The ordinary collection contains the rare insects as frequently as it does the destructive ones, and by that he meant to uphold the question that was raised in the address with reference to how many of the common insects could be found in different collections. He suggested, that so far as his own experience goes, there are too few collections in which all stages are preserved in connection with the work that insects do. A large part of the material that he receives in Massachusetts does not contain any insect whatever, but simply a sample of the work of the insect which has either escaped from the box or was never inclosed. The problem in such cases is to tell what has done the damage by the damage itself. He found that his greatest help was to preserve specimens of the insect and of the work it was doing, and he used such specimens in the identification of material sent in perhaps fifty times as often as any other specimens. Our collections, in his opinion, should be amplified along the lines of early stages and the work done by the insects, and such collections will appeal strongly to the people. The whole address was interesting and suggestive, but it was this feature which interested him most. He had also had experience with the *Murgantia* parasite obtained from Louisiana by the kindness of Mr. Morgan, and while he was now fortunate in not having *Murgantia* to deal with, it was a great relief while searching around to find that there was some one who could assist him, and he thought anything in that line should be encouraged, for when a man wants a thing of that sort he wants it badly.

Mr. Johnson said there was another important suggestion implied in the address, and that was the commercial side of entomology if the term might be permitted. We have enough systematic entomologists at the present time, and perhaps enough economic entomologists, but we do need another lot of men who will take up purely the ecological side; that is, they must study conditions in the field. The day is coming, and is not far distant, when our great commercial railroads and some of our greatest manufacturing concerns, such as canneries, will employ ecological entomologists just as they employ engineers and other skilled labor. He felt quite certain that this would come about, and that a new field would open to young men especially who would take up this commercial side of the entomological problem. To give an illustration of what he meant, he said he would try to bring this out in a paper which he would read on the following day on the subject of the pea louse in Maryland, which has destroyed more than \$4,000,000 worth of green peas along the Atlantic coast this season.

When insect injury touches the pockets of the producers to that extent they are going to look around for the men who are looking after the bugs. It means money to them. He had been in consultation with some of the high officials of one of our principal railroads, and felt certain that the day is not far distant when these roads will employ men to take up the entomological study and development of the territory through which their lines run. He considered this an important point for the student of entomology to bear in mind in the future. Of course such a man must go out and study conditions over a vast area. He must also know what our worthy chairman is doing in Colorado; what Mr. Weed is doing in New Hampshire; what Mr. Lounsberry is doing in South Africa; what Mr. Fletcher is doing in Canada—in short, he must keep posted on the entomology of the whole world and be ready to meet any emergency.

Mr. Hopkins said that along this same line he might mention the fact that he found in the spruce forests of Maine that a large timber concern controlling some 300,000 acres employed a practical forester and scientific man, and paid him about \$1,500 a year, to give advice on practical methods of cutting timber and making surveys. The concern mentioned sent this man with Mr. Hopkins through the spruce forests of Maine to learn all he could about forest insects. This was another evidence of the fact that the practical men are beginning to realize that they can very profitably utilize the results of scientific research.

Mr. Kirkland said that if the members of the Association knew the circumstances under which the presidential address was prepared they would appreciate it all the more. Mr. Bruner decided at a rather late date that he would be unable to be present, and Mr. Gillette very kindly consented, on short notice, to write an address. It was a matter of congratulation to the members of the Association that they have in their membership one who was both willing and able to do so good a piece of work at such short notice.

Two papers were presented by Mr. Weed, as follows:

ON THE OVIPOSITION OF AN EGG PARASITE OF VANESSA ANTIOPA.

By CLARENCE M. WEED, *Durham, N. H.*

[Abstract.]

One May morning at Durham, N. H., a *Vanessa antiopa* was seen ovipositing on *Salix*. After laying about twenty eggs she flew away. The moment she left, a small hymenopteron—since identified by Dr. L. O. Howard as *Telenomus graptæ* Howard—was seen running over

the eggs. The parasite was watched for the next half hour, during which time it oviposited in fifteen eggs. Does the parasite ride around on the butterfly, waiting for oviposition?

ON THE OVIPOSITION OF *CACÆCIA CERASIVORANA*.

By CLARENCE M. WEED, *Durham, N. H.*

[Abstract.]

The eggs are laid in flattened masses on the bark of chokecherry shrubs very near the ground. The egg mass at first is yellow, but later it becomes brownish, so that it is very difficult to distinguish it from the bark. There is but one brood of larvæ a year, the eggs laid in summer remaining unhatched until the following spring, then the young larvæ crawl to the top of the shrub, where they begin the construction of the tent.

The next paper was entitled:

THE RELATIONS OF *PIMPLA CONQUISITOR* TO *CLISIOCAMPA AMERICANA*.

By CLARENCE M. WEED and WILLIAM F. FISKE.

[Abstract.]

Pimpla conquisitor is the most important hymenopterous parasite attacking the pupa of *Clisiocampa americana*. The eggs are commonly laid in the cocoon of the host soon after its construction, and several experiments conducted with a view of ascertaining the invariability of this rule go to show that exceptions are at least rare. The development of the parasite from the egg takes but little more time than that required for the completion of the metamorphosis of *Clisiocampa* after constructing its cocoon, so that their respective dates of emergence are not far apart. The pupa shell of the host is completely filled by the larva of its parasite when the latter is full grown, but after the discharge of the semisolid meconium it is scarcely half as large as before.

The larvæ of *Pimpla* are attacked when nearly or quite full grown by a secondary parasite, *Theronia fulrescens*, the larvæ of which feed externally upon their host and finally replace it. The various stages of this species from the first have been observed and many specimens reared. It is about two weeks in reaching maturity from the egg. A peculiar fact noticed in the observations upon this species is that in the first stage from the egg the minute larva has a hard chitinous head with large jaws, a feature totally lost in the succeeding molts.

Another interesting point in connection with the life history of *Pimpla conquisitor* is the fact that it occurs both as a primary and a secondary parasite on the same host, *Utiocampa americana*. Very small individuals were bred from several species of primary parasites attacking the immature caterpillars, the species most commonly acting as host in this manner being *Limneria fugitiva*.

The next paper, by Mr. Fernald, was entitled:

ON THE MARGUERITE FLY.

By H. T. FERNALD, *Amherst, Mass.*

[Withdrawn for publication elsewhere.]

Replying to a question from Mr. Johnson, as to whether hydrocyanic-acid gas had been used, Mr. Fernald stated that there was objection to the use of this substance among florists, who have an exaggerated idea of the danger involved and will not often use it. He had no doubt hydrocyanic-acid gas would be more effective, but thought the florists would prefer to use carbon bisulphide, as this substance had proved satisfactory.

Mr. Fletcher thought that remedial work against the flies during the winter would be better than work against the larvæ after they have eaten the leaves.

Mr. Fernald replied that the problem had been thus far looked at by him entirely from the florists' standpoint, and the insect treated in the stage at which the florists would first see it and want to treat it. He was certain, however, that the fly could be handled by fumigating the greenhouses.

Mr. Woodworth said that the fear that exists in the East over the use of hydrocyanic-acid gas was looked upon by many Californians as very funny. In his State the greenhouse man will pick up his material in his hands, charge his vessel, walk out deliberately, and close the door after him.

Mr. Johnson stated that one could not be too careful in the use of hydrocyanic-acid gas, and he wanted to caution all those who used it. In one instance, after preparing the chemicals necessary for generating the gas, he thought he would take his chances in dropping the cyanide in the jar and get out, but he felt the effects of the gas almost immediately. By the time he reached the door a haze came over his eyes, everything looked black, and a feeling similar to blind staggers overcame him. Experience has proved that it is not a trifling matter, and he would caution all who had occasion to use the gas. At the same time he felt that hydrocyanic-acid gas was the coming material for the destruction of certain insect pests in mills where stored grain and

other products become infested. He had recently performed one of the largest experiments ever undertaken in the use of hydrocyanic-acid gas, in a five-story brick mill in Canada. Over 150 pounds of potassium cyanide was discharged in the mill, and the results were very gratifying. It practically eliminated the flour moth from the mill.

Mr. Fletcher said he did not think enough care could be taken in giving instructions when recommending hydrocyanic-acid gas for general use, especially in this stage of introducing it, as a fatal case or two would put an end to its use entirely. Several striking instances had lately been mentioned which show the intensely poisonous nature of this gas. Much more care, instead of less, than has been exercised in the past is necessary. With regard to the use of bisulphide of carbon, he certainly was not satisfied with its use in mills, and had not got the results promised for it. He was very sorry Mr. Marlatt was not present at the meeting, as his *laissez-faire* policy had given him a lot of trouble with the people he had to deal with, and he was of the opinion that some others of the Association might have liked to discuss that matter somewhat.

Mr. Sanderson suggested the use, in cases where only a small amount of the gas is required, of gelatine capsules, which require about one minute to be eaten through by the acid, thus giving time to get the box closed.

Mr. Webster stated that his fumigating houses in Ohio are covered carefully and made perfectly air-tight by the use of layers of building paper, but if the ordinary nurseryman makes his own fumigating house he would not make it any more air-tight than a hencoop. He had tried almost every way of introducing the cyanide, but the man who did the work invariably complained of severe headache, until he devised a method of combining the mixtures under the floors.

Mr. Lounsbury suggested that a simple way was to have a small lead tube leading from the outside of the house, the vessel containing the cyanide being placed under the tube, the door closed and locked, and the water and acid freshly mixed being poured in through the little funnel or tube and the aperture closed.

The next paper was entitled:

OBSERVATIONS ON *DIABROTICA 12-PUNCTATA* OLIV.

By A. L. QUAINANCE, *Experiment, Ga.*

In the Southern States particularly this insect is a corn pest of considerable importance. Injury to the corn plant is confined almost entirely to the work of the larvæ on the underground portions of the plant, as the roots and stem below the soil. Injury results to corn

most manifestly, if not mainly, during the spring of the year, while the plants are quite young; and it is a common observation of farmers, throughout Georgia at least, that the plants on low, wet soils are much more seriously damaged than corn planted on uplands. The extent and nature of the injury may vary, but the most usual symptom of the work of the larvæ is in the wilting and falling over of the central leaves, or "bud," of the plant, and later becoming brown and dry. Plants showing this appearance when examined are almost invariably found to have been bored into at the base of the stem in such a way that the central and vital part of the plant has been more or less cut free from the tissue below. This wilting and dying of the central roll of leaves of the corn plant has doubtless suggested the term "bud worm," by which name the larvæ seem to be very generally designated. Other terms, as "bill bug" and "wire worm," are less frequently used in speaking of this insect. The recognized English name, the Southern corn root-worm, as used by entomologists, I have never heard used by planters.

Not all plants showing the wilted "bud" have necessarily been injured by the Southern corn root-worm, as in frequent cases wire-worms have been found to be the cause of the trouble. Less usually the white ant, probably *Termes flavipes*, has been found to have eaten into the stem near the surface of the ground, chewing out relatively large cavities. Injury from white ants has been most common in fields planted to cotton the previous year, and the decaying stalks on the ground have in most cases been close to or in contact with the infested corn plant.

Prof. F. M. Webster was probably the first to indicate the injurious character of these larvæ on corn, in the Report of the Secretary of Agriculture for 1887 (p. 148). Mr. Webster's observations were made in Louisiana, and while from the article referred to it is not apparent whether the larvæ observed were actually bred into the adult condition or not, there can be no reasonable doubt from his description of the larvæ and their injury but that these were larvæ of *Diabrotica 12-punctata*.

There is good reason to believe, however, that this insect has been injurious to corn, in Georgia at least, many years before we find any reference to it in the literature of economic entomology. Several different Georgia farmers, who are quite familiar with the larvæ and their work, affirm that they have known the "bud worm" ever since they can remember, which in some instances could reasonably be expected to extend back over a period of at least fifty years.

The years 1889 and 1890 witnessed a rather general outbreak of this insect, and the injury to corn attracted attention over quite a large area of country, including Illinois, Indiana, Ohio, and most of the Southern States. This outbreak was the occasion of a careful

study of the pest, and from 1890 to 1893 several important contributions were made to our knowledge of the insect, notably by Prof. H. Garman, Dr. S. A. Forbes, and Dr. C. V. Riley. The economic bibliography of *Diabrotica 12-punctata* includes some thirty references, though many of these are brief notes relative to the food habits of the adults.

During the present spring the insect has been quite abundant in Georgia, and it has been the object of considerable complaint, not only on account of injury to corn by the larvæ, but on account of injury to the foliage of various plants by the adults.

The first beetle observed by the writer was on March 12, when a gravid female was found in a road extending between two fields of fall-sown oats. March 13, twenty minutes' sweeping of a rye field gave two dozen beetles, all gravid females. Some of these deposited numerous eggs in the vials by the next morning. On March 22 but few beetles were to be found, owing to the cool weather, but on March 28 they were exceedingly abundant, feeding on rye, oats, and alfalfa. Something like seventy-five were captured in a few minutes' sweeping of alfalfa. The females captured were almost all heavy with eggs, these showing plainly through the abdomen as apparently fully developed. Subsequent occasional sweepings of alfalfa and rye indicated that the beetles were most abundant about April 10, after which date there was a very pronounced decrease in the number captured, and many of the beetles captured had evidently oviposited.

Most corn planted on the station had made its appearance above the soil by April 14, and careful examination was made almost daily to detect the beetles in the act of ovipositing. No beetles, however, were observed in the cornfields until the 19th, when three were captured, one gravid, the other two having evidently oviposited. By the 24th, beetles were much more abundant in cornfields, and were no doubt ovipositing, though I could never detect them in the act. An hour's search with a "bull's-eye" lantern on each of two different nights, in fields where beetles had been somewhat numerous during the preceding afternoons, failed to find the beetles ovipositing. They were apparently, on the other hand, not active, many of them in more or less secluded situations. Beetles were observed to be more numerous on the higher parts of cornfields than on the bottoms, which is the opposite of what would be expected, since the larvæ are undoubtedly more numerous in wet bottom soils than elsewhere. It is a prevalent opinion among farmers in Georgia that eggs are deposited during the cool nights of April, and it may be that eggs are deposited mainly at night. Early morning search for beetles has never revealed them active, but in secluded situations, as within the young leaves of a corn plant or under trash on the ground, and they have not been observed to be active until warmed up by the morning's sun. While

in the cornfields the beetles do not feed on the young corn plants to any extent, but on seedling weeds. They have been observed repeatedly to leave corn plants and crawl here and there on the ground until finding a seedling weed, when it would be eaten down close to the ground.

The first signs of injury to corn were observed May 2, when numerous wilted buds were discovered in a low plat of corn on a low situation on the farm. Larvæ found at this date were most of them about one-third grown; two were found, however, almost, if not quite, full grown. The two weeks of hot and dry weather following this date caused a general wilting of plants badly injured in the crown, and frequent examinations of the roots of infested plants were made. It soon became apparent that a rather small proportion of the larvæ among the roots of plants attacked the crown, causing the death of the plant; but that, probably in the majority of cases, the larvæ fed on the roots or on the outside and under the stem at the origin of the roots. Rarely were the roots channeled out longitudinally, but more usually eaten into or eaten quite off. On the side of and below the stem of a corn plant in four or five leaves channels or grooves may be eaten, the larvæ not attempting to bore into the heart. Where such is the mode of attack, the outer leaves are likely to appear more or less yellow or rusty in blotches, or even yellow and dry. When the roots only are attacked but little injury seems to result to the corn; in fact, many of the most thrifty plants pulled up and examined had as many as five and six full-grown larvæ among the roots. In a word, larvæ were found quite generally among the roots of most plants on low soils, as many as three to six to each hill, and in a relatively small proportion of cases were plants attacked at the crown, causing the usual wilting of the bud.

The first pupa found in the field was May 8. On May 10 a rather extended search proved them to be quite numerous. The first beetle of the new brood was observed May 12, from which date they have become increasingly abundant. At this writing, June 12, beetles are quite abundant, feeding mainly on the blossoms of various cucurbits.

The last stragglers of the over-wintered brood had disappeared by the last week in May. The broods are thus seen to overlap somewhat, but it is likely that these stragglers passed the winter as larvæ or pupæ, completing their development in the spring.

Beetles have been observed feeding on the foliage of the following plants: rye, oats, alfalfa, corn, crimson clover, currants, gooseberry, and such garden vegetables as beans, beets, squash, cantaloupes, watermelon, cabbage, Irish potatoes, turnips, tomatoes, and on the flowers of apple, pear, quince, plum, peach, and cherry. In fact, the beetles seem to be practically omnivorous. Larvæ have been found on the roots of corn, rye, *Bromus uniloides*, and garden beans. On this latter crop considerable injury was done, larvæ boring into the stem and

eating out channels up the stalk, frequently up to the seed leaves. The beetles were very injurious to apple bloom, and doubtless aided much in the general distribution of pear blight that has occurred in Georgia this year.

LABORATORY OBSERVATIONS.

Egg laying was repeatedly observed in the breeding cages. In ovipositing the stylus-like ovipositor is pushed down into the soil to a depth of from one-eighth to one-fourth of an inch, where it is held until the egg is forced down the extensible oviduct and out at the opening at the base of the ovipositor. This requires usually but a few seconds, and after moving a short distance another egg may be deposited. The writer has observed a beetle thus deposit fifteen eggs in quick succession. Occasionally the ground is found too hard for penetration, when another trial is made. Ordinarily but one egg seems to be deposited in one place, but occasionally two to four may be found together. In close quarters, as in a vial, or even under a medium-sized lamp chimney, twenty to thirty eggs have been found together in a mass. An individual gravid beetle confined by itself usually deposits the majority, if not all, of its eggs in a few hours, and my observations as a whole incline me to believe that a beetle normally will deposit its eggs in the course of one or two days.

Many dissections of gravid beetles show that the number of eggs may vary from 62 to 87, with an average of about 75.

Eggs secured March 14 hatched April 14; eggs secured March 29 hatched April 20, and eggs secured April 24 hatched May 16. The variation is doubtless due to the difference in temperature. Just-hatched larvæ are quite agile and make their way readily through the soil. Larvæ placed on the roots of corn plant in one end of a root cage, after the destruction of the corn, made their way through the soil to a plant in the other end of the cage, 10 inches distant. Larvæ may also descend some 8 or 10 inches below the soil, searching for food, as was witnessed at different times in the root cages.

The larvæ hatched from eggs, previously mentioned, on April 14, pupated May 12, spending five to seven days in the earthen cell before pupating. The adults appeared May 21, the life cycle in this case extending over a period of about nine weeks.

In another batch bred through eggs secured April 25, hatched May 3, the larvæ pupating May 27, adults appeared June 5, thus extending over a period of forty-one days, or about six weeks.

EXPERIMENTS WITH MEANS OF CONTROL.

Two areas were chosen of about one-half acre each, on low and moist soil, on which to test the effect of different methods of planting and the effect of the use of different insecticidal substances. Each area was divided into 27 plats, and treatment for the two areas, plat

for plat, was the same, thus duplicating the work on two different situations on the farm. Without going into detail, I will mention some of the ways which the plats received treatment. Corn was planted deep, shallow, early, late, with an excess of seed in the hills, and drilled. In one plat the earth was listed over the corn just as it was coming through the soil. In another plat the earth was thrown away from the corn as much as possible, thus exposing the lower part of the stalk somewhat. Plats were planted with seed corn soaked in strong kerosene emulsion, in diluted kerosene emulsion, and in chloride of lime. Other seed were coated with tar and with sulphur made adhesive by moistening with molasses. One plat was treated with kainit, at the rate of 2,000 pounds per acre, just as the corn was coming through. Another plat was sprayed with kerosene emulsion around the hills as corn appeared above ground. In still another plat a handful of tobacco dust was placed in each hill at the time of planting seed.

By May 12 the corn was mostly 10 to 12 inches high and the majority of larvæ were from two-thirds to full grown. At this date sixteen hills from each plat were carefully dug up, the larvæ counted, and the nature and extent of the injury noted. In this work it soon became apparent that the various methods of treatment, except late planting, and the different insecticides employed appeared to have no appreciable effect in reducing the number of larvæ as compared with the untreated checks. Injury resulted to seed corn soaked in strong kerosene emulsion for six hours, about 60 per cent failing to germinate. Curiously enough, the plats receiving kainit at the rate of 2,000 pounds per acre gave a larger per cent of larvæ than any of the others. This may have been due to the moister condition of the soil, following the use of this fertilizer.

Corn planted May 4 was but little injured, by this date, the beetles mostly having deposited their eggs.

In the case of plats, where an excess of seed (8 to 10) was dropped in each hill, in no case were all of the plants in a hill destroyed, sufficient plants being left for a good stand, and in most hills thinning out was necessary. In plats where the corn was drilled the injury was relatively small. From this season's work it appears to the writer that if bottom lands are planted to corn late, as the first of May, or, if eight to ten grains be dropped in each hill, injury from the Southern corn-root worm may be practically avoided or so distributed that the damage will be inconsequential.

In discussing this paper Mr. Webster said that last fall he had stepped off a portion of a strawberry bed badly infested with white grub and applied kainit at the rate of 4,600 pounds to the acre, but when he came to count the grubs he found more in the portion upon which he

had applied the kainit. He could not see any reason for considering kainit an insecticide. He had tried it for white grubs, strawberry root borers, rose beetles, and wireworms and could not see that it had any effect upon any of them. If it killed one single individual he was not able to see it.

Mr. Lounsbury said he thought there was a great deal to be said against kainit and a good deal to be said in its favor. Perhaps weather conditions immediately following the application may have something to do with its efficacy. For instance, a rainfall might add to its insecticidal value.

Mr. Webster stated that he had taken particular pains to apply water to carry the kainit down, but without effect.

Mr. Lounsbury presented the following paper:

NOTES ON SOME SOUTH AFRICAN TICKS.

By C. P. LOUNSBURY, *Cape Town, South Africa.*

The purpose of these notes is to present briefly the more important of a number of observations made in recent studies on the habits and associations of several species of South African ticks. The notes are made from memory, and, lest errors should creep in, detailed particulars are not attempted. The primary object of the studies was strictly economic, it being to obtain data that would assist in determining the courses best adapted for the suppression of the ticks. Some of the species have long been a deterrent to stock farming in certain parts of the Cape Colony, and of late years have increased to an extent that threatens the progress of the cattle industries in several districts. There had been, moreover, a suspicion of long standing in the country that one, at least, of the species was in some way associated with a generally fatal sheep and goat disease known as "heartwater." This disease during the last half century has gradually become extended over a tract of country in the southeast of the colony which was once capable of supporting several millions of sheep. The fowl tick considered is a poultry pest common to many warm-temperate and sub-tropical lands. It is the *Argas americanus* of the Southern United States.

THE BONT TICK.

The tick of greatest importance, because of its injuries to stock, is *Amblyomma hebraeum* Koch, commonly known as the bont tick. "Bont" is a Dutch word, equivalent to "variegated," and its application in this case has reference to the mixed coloring on the back of the male. The bont tick is supposed to have spread into Cape Colony from the eastward between sixty and seventy-five years ago, and it is still restricted to southeastern districts—the same districts in which the heartwater disease occurs. It is the largest of South African

ticks, and perhaps is of unrivaled dimensions. The American cattle tick is a mere pigmy in comparison. The bont female measures up to an inch in length, three-fourths of an inch in width, and half an inch in thickness. After engorgement she drops from her host and secretes herself. In soft sand she may burrow an inch or two downward, while in harder soil or in rubbish she may rest content after burying the forepart of her body. She lays her eggs in a compact mass anterior to herself in this retreat and dies at her post after the completion of the task. Exceptionally large females probably deposit as many as 20,000 eggs; a careful estimate on one batch of eggs obtained in confinement placed the total number at about 17,500. Oviposition, incubation, and all the other periods in the life cycle off of the host vary in duration with the temperature of the surroundings. Development in these stages proceeds all through the year, but is many times more rapid in summer than in winter. The winter season in the area infested is mild and dry, without snow and with but few hard frosts. The young ticks ascend the grass, bushes, or other support above them and there patiently await a host. The passage of animals in their vicinity, by means not yet satisfactorily determined, arouses their attention and incites them to run about clawing the air with their forelegs. Attachment to a passing object is secured by the waving legs, but a large proportion of the tiny creatures are brushed off again almost immediately. Such unfortunates must, perforce, await other opportunities. If the passing object prove a host those that contrive to maintain their hold soon find the skin and inserting their rostra proceed to gorge themselves on the blood. The operation of engorgement ordinarily requires about six days. Except as regards the duration of the different periods, the habits of the bont tick from the dropping of the female to the engorgement of the larva coincide with those of the American cattle tick; thereafter, however, there are differences. The bont larva when replete with blood withdraws its rostrum, drops from the animal and undergoes its metamorphosis in hiding on the ground. Sixteen days or longer, according to the temperature, pass before the larval skin ruptures and the eight-legged, flat-bodied nymph appears. The nymph seeks a host not alone through patient waiting and waving of its claw-armed forelegs but by running about on the ground when an animal is near. Engorgement is again completed about the sixth day and the tick then bears a superficial resemblance to the gorged female of the common cattle tick; it is, however, shorter and relatively broader and of a different shade of blue. Voluntary dropping and, after an interval of eighteen days or longer, a second molting follows. The tick has then reached the adult stage. The sexes, which were indistinguishable in the earlier stages, may be told at a glance when adult. They have similar dimensions, but the markings and colors are dissimilar, and the shield of the male,

as is characteristic of the Ixodidae, covers the entire dorsum, while that of the female is restricted to a small area above the rostrum. The adult bont tick is seldom found on bushes or grass, and it appears that it seeks a host solely from the ground. The male takes up a position independent of the female, and after several days, generally four or five, he makes known by straightening his body and waving his legs when one of the opposite sex approaches him that he is prepared for a mate. The female, without having previously fed, searches about until an eligible male is found, and on finding one embraces him and installs herself on the skin with her ventrum opposed to his. When an unpaired eligible male is wanting the female may attach herself by a mated couple, but she rarely settles down distant from one of the other sex, and her evident object in settling by a couple is to secure the male after the other female leaves. In about eight days from affixing herself to a host, or longer if a mate is not at once secured, the female becomes fully distended with blood and drops. The male becomes somewhat thicker in body but no longer or wider, and appears to subsist not on blood but on products of suppuration in the wound he makes. He may remain for many months in the one position and mate successively with a number of females. One specimen under observation has been attached over seven months. The two sexes are produced in approximately even numbers, but the males appear to predominate, owing to their longer attachment.

How copulation is effected has not been determined with certainty. It is conjectured that the female protrudes an organ by invagination, which is brought into intimate contact with the sexual orifice of the male. Mr. Claude Fuller, the Natal entomologist, called my attention to the probability of this unique means for intercourse with respect to another Ixodid, and since I have repeatedly witnessed the quick retraction of a protruded organ by the female of the bont and several other Ixodidae when separating couples. The invagination may be similar to that which occurs in the process of oviposition. The male orifice in the bont and some other species is beneath a rounded, lid-like shield which opens forward, and when males have been suddenly parted from their mates this shield has oftentimes been observed to be raised. Females do not appear able to complete their engorgement until they have mated.

The bont tick infests cattle, horses, sheep, goats, and ostriches, and probably various other animals, as on the evidence of farmers it is not infrequent on old or weakened buffaloes and other kinds of horned game. It attaches itself to man occasionally, and now and again is found on the barnyard fowl. Curiously, mules seem to become less infested than horses. That it may mature and reproduce when reared on horses, cattle, and goats has been established, and that it may fully engorge itself, both as a larva and nymph, on ostriches and afterwards

successfully molt has also been affirmed. The adults are rarely found on the back or high on the flanks of the animals. They get most numerous on the relatively hairless parts under the shoulders, between the thighs, about the genitalia and anus, and on the udder. The larvæ and nymphs prefer the same situations, but a few also get on to the back and flanks; of all parts they appear to prefer the feet. The adults are considered responsible for the formation and spread of sores. Such sores on calves may involve and destroy the teats. So serious is this evil that on some farms a milch cow with a sound udder is exceptional.

All stages of the bont tick may fast many months while awaiting a host. Larvæ have remained alive fully seven months in a cork-stoppered bottle, and a single adult an equally long time. Females forcibly detached from a host without injuring the rostrum may survive and lay fertile eggs, even if only half engorged. Males thus detached rapidly lose vitality and generally succumb within three days, but while they have life they lose no opportunity to again attach themselves, and do not hesitate to then attack even the hand of a man. The method of piercing the skin may be easily followed in the case of such specimens.

By a carefully conducted experiment the bont tick has been found by the writer to transmit the heart-water disease alluded to in the opening paragraph. Larvæ were reared on diseased goats. As nymphs these ticks were placed on healthy goats and the disease produced. In one instance ten ticks transmitted the infection. An account of the experiment is given in the Cape Agricultural Journal for May 24, 1900. It appears probable that the bont tick may also communicate "redwater," the disease known in America as Texas fever. A cow purposely infested with a few specimens which came from a redwater area contracted the disease when no other possible source of infection appeared present. The circumstances surrounding the incident are given in the writer's annual report for 1899 (Report of Entomologist, Department of Agriculture, Cape of Good Hope).

THE BONT LEG TICK.

The second largest common South African tick is *Hyalomma aegyptius* Audouin. The Dutch colonists know it as "Bontepooten," a term suggested by bands of white on the legs of the adults, and from this term is taken the English colonists' name here adopted. This species is found all over Cape Colony, but is best known in the dry, inland districts. It occurs in other parts of Africa and elsewhere. The fully engorged female sometimes measures four-fifths of an inch in length and over a half inch in width. The life cycle has not been traced, but scattered observations indicate that the molting and host-securing habits are similar to those of *Amblyomma hebraeum*. The

hosts, too, are the same. It is more frequently a subject for complaint with sheep, goat, and ostrich farmers than with cattle farmers, but perhaps this is because it chances to be naturally more abundant in the districts where the kinds of stock first mentioned are farmed. It infests much the same situations on the hosts as the bont tick, and is a frequent cause of lameness, particularly in sheep and goats. Males predominate on a beast and remain a long time. The various periods of the life cycle, so far as these are known, are all of shorter duration than the corresponding periods with the bont. There is presumed to be, ordinarily, one full generation in the course of a year. This species, as an adult, appears to far oftener attach to man than other South African Ixodidae. The larvæ of the different species seem about equally troublesome in this respect, and make the life of some people in tick districts one of frequent misery.

THE BLUE TICK.

“Blue tick” is a convenient popular name for *Rhipicephalus decoloratus* Koch, but in reality the color of the replete female—the stage in the life cycle most commonly observed and the one suggesting the name—is nearer slate-gray than blue. This species is a close ally to the common cattle tick of America, *Rhipicephalus annulatus* Say, or, as it is more familiarly known, *Boophilus bovis* Riley. Prof. G. Neumann has stated to the writer that in a forthcoming supplement to his monograph on ticks he expects to class the South African species as a variety of the American. There are, however, a number of constant structural differences between the two ticks, as shown by Mr. Claude Fuller in the Queensland Agricultural Journal for May, 1899, pages 389–394.

The blue tick is by far the most abundant of South African ticks. It is found almost everywhere in Cape Colony, and sometimes occurs in such numbers on cattle as to quite obscure large areas of the skin. Few farmers, however, regard it as of really serious importance; and while it doubtless severely taxes the strength of animals when continually abundant on them, it does not ordinarily appear to affect their condition and certainly does not worry them to near the extent that the two larger species do. Occasionally, nevertheless, calves are reported to be stunted in growth and even destroyed. Since this species is probably the common agent for the transmission of South African redwater (Texas fever) as is surmised, it may be of interest to record that it occurs in abundance on cattle in many places to which the disease has yet to spread.

The changes from larva to nymph and from nymph to adult take place on the host. Both stages feed three or four days and then remain quiescent about the same length of time with the rostrum still affixed to the flesh. The nymph settles near the larval skin and the

adult female, too, does not usually wander far. The sexes look much alike at first despite the structural differences. The mating habits are still in doubt, but numerous females have been observed to have settled alone and to have later been joined by males. Dating from the attachment of the larva the females begin to drop in about twenty-four days, and most of them are off by twenty-eight. It takes but a short time, only a week or ten days in midsummer to prepare the dropped females for oviposition and within the limits of three summer months one life cycle may be completed and a second begun. Larvæ have been observed to remain on grass tops awaiting a host through high winds, rains, and light frosts. Over 2,000 were counted at the top of a single spear of grass.

Cattle, horses, sheep, and goats are attacked by the blue tick. It matures on all in numbers, but the cattle acquire it in greatest abundance. The progeny of specimens from a horse have been reared on a cow; that of specimens from a cow on a goat, and that of specimens from a goat on another goat. The young ticks appear practically indifferent to what part of the animal they attach, yet wander more when liberated on a beast than do the larvæ of some other species.

THE RED TICK.

The red tick, *Rhipicephalus cecruti* Neumann, takes its common name from the color of the adults of both sexes prior to engorgement. It has a wide distribution in South Africa and all classes of farm animals are attacked by it. Its attack is generally regarded as of no consequence, but some intelligent farmers attribute a temporary paralysis of the limbs of sheep and goats to it; when the particular tick responsible for the trouble is removed, an afflicted animal quickly recovers. It is rarely that an ox, sheep, goat, or horse running on unimproved grazing ground in Cape Colony is entirely free of this species of tick. Although the red tick is classified as congeneric with the blue, the habits of the two are very dissimilar. The larvæ of the red tick have a decided preference for the inner surface of the ears, and comparatively few are found elsewhere on an animal. After three or four days feeding ceases, and about the seventh day the nymph appears, as with the blue tick; but with repletion in the nymphic stage the tick withdraws its rostrum, drops, and molts on the ground, after the manner of the bont tick. The adults, in order to obtain a hold on a host, habitually rest at the top of a spear of grass or at the end of a twig and extend their forelegs when disturbed. This habit, though common to the larvæ of all the Ixodidae mentioned in these notes, has been observed only in the adult of the red tick and two congeneric species, *R. capensis* Koch and *R. bursa* (?). Only hairless parts of an animal attract the adults, and the region adjacent to the anus draws more of them than all the remaining surface of the body. Partic-

ularly is this remarkable fact true of goats. In an experiment which involved the feeding of nearly a thousand adults on four ewes practically every specimen attached itself near the anus or vulva. The two sexes are produced in nearly even numbers from a batch of eggs. Each settles on a host without regard to the presence or absence of the other; but after a few days of feeding, if females be at hand, the males release their hold and seek mates. Unmated females cease to swell after a few days and remain less than half engorged until found by males. Mated females swell very rapidly during the day prior to their dropping, often quite doubling their dimensions. The dropping normally occurs on the sixth or seventh day. The females are then somewhat larger in all their measurements than the blue females.

OTHER IXODIDÆ.

Some species of ticks are said to be restricted to a single host or to hosts generically allied, and on this account it may be of some interest to record that *Amblyomma devium* Koch, a tick often found on tortoises and snakes in Cape Colony, has been removed from an angora goat. Two specimens only, one of each sex, were obtained as engorged nymphs. The determination of the species is by Prof. G. Neumann, to whom it may here be acknowledged I am indebted for affirmation of the determination of all the species mentioned in these notes.

Another observation worth record here has been made in regard to *Ixodes pilosus* Koch. The male of this species seeks the female and establishes himself on her ventrum with his rostrum buried in what appears to be her sexual orifice. If separated he seeks to resume the position. Mr. E. J. Wheeler, of Alnwick, England, has observed this puzzling act in another species of *Ixodes* and believes it to be that of copulation. *Ixodes pilosus* is about the size of the blue tick. It has been taken from cattle, horses, goats, and hogs. It leaves its host to molt on both occasions.

THE TAMPAN TICK.

The "tampan" is an Argasid, *Onithodoros savignyi* Audouin. Its life cycle has not been traced, but among collected specimens there appear to be at least four life stages; that is, one more than occurs in the Ixodid ticks. The tampan is a most repulsive creature in appearance, with an extremely tough, leathery skin and stout, curiously sculptured legs. The sexes can be distinguished only by examining the genitalia; at least no other certain way has been discovered. When fully engorged, the female measures up to half an inch in length by almost as wide and half as thick. Horses, cattle, sheep, goats, and man are commonly attacked by this tick, and scores of specimens liberated near a confined barnyard fowl fed to repletion on that animal. The feeding habit of the larvæ has not been observed. Thirty or

forty which hatched in a cardboard box molted therein to an eight-legged form without having partaken of food. The other stages, to draw conclusions from observations on captured specimens afterwards fed on a fowl or goat, attach themselves by night or day to the host and gorge themselves to repletion in from one-half hour to two hours. They then crawl away and hide. The females alternate egg laying with feasting. The tampan is widely distributed in South Africa, and in some sections is a sore trial to travelers.

THE FOWL TICK.

The fowl tick of South Africa has been identified by Professor Neumann as the historic *Argas persicus*. It is a flattened, ovate creature, with a peculiarly stippled dorsal surface. It measures about two-fifths of an inch when full grown. Poultry, geese, and ducks are commonly afflicted with it, and death from loss of blood sometimes follows severe attacks, particularly in the case of young birds. Man is sometimes attacked.

This tick molts its skin three times before becoming adult. The eggs are laid loosely in crevices. The hexapod larva crawls to a host, affixes itself, and remains attached nearly a week. The body meanwhile distends with blood, and, toward the last, undergoes a change of form which gives it the general appearance of the later stages. When fully engorged, the larva crawls off and secretes itself in some crevice or under the bark of a tree preparatory to molting. In its later stages the tick normally visits its host in darkness, remains but an hour or two, and during this short time distends its body fully. One visit only intervenes with a molting. The adult male enlarges but little. The adult female increases all its dimensions with its first feast after the final molt, and later appears to simply fill itself out to the size then attained. It alternates feeding with egg laying. A score or more of specimens under observation and fed on a caged fowl have thus alternated feasting with oviposition four times. Intercourse between the sexes has only thrice been observed. In all three cases the male had his rostrum inserted into the female. Large numbers of both sexes have been fed and kept boxed in company, and as only the three pairs have been seen together, some observations of importance probably remain to be made. Less than three weeks need intervene between the feastings of the nymphic stages and a month those of the adults.

The vitality of the fowl tick is remarkable. It resists insecticides, even hydrocyanic-acid gas, far more than the bedbug or other proverbially hard-to-kill pests. The larvæ may be soon starved to death, but the later stages live on through months of fasting and succumb only when shriveled to a dry shell. Several have remained alive over a year in cardboard boxes on my office desk.

Mr. Southwick having invited the members of the Association to inspect his spraying outfit in Central Park, it was voted to accept his invitation and to visit the park, for the purpose mentioned, at 1 p. m. on June 23.

The next paper was presented by Mr. Scott:

NOTES ON COCCIDÆ OF GEORGIA.

By W. M. Scott, *Atlanta, Ga.*

Since March, 1898, the writer has worked the State of Georgia over with the secondary purpose of making a collection of the scale insects occurring within the bounds of the State, and the following is a list of the collected species, with brief notes on their habits.

(1) *Aspidiotus perniciosus* Comst.

This, the San Jose scale, is without question the most important species, economically, that occurs in the State, and there are perhaps more trees infested with it here than in any other State in the Union. Our records show 200 cases of this scale (principally commercial orchards), involving over a half million trees (peaches and plums). This does not include the garden and wayside cases, of which there are hundreds in some of the lower counties. These cases are distributed over 32 counties, principally in the southern part of the State, only 5 counties north of Macon having been found infested. Its food plants in Georgia are recorded as peach, plum, apple, pear, *Prunus pissardii*, rose, grape, pecan, Kilmornock willow, cottonwood, and Carolina poplar. Robinson and wild-goose plums and LeConte and Kieffer pears do not seem to be congenial host plants for this insect. These varieties, growing in the same orchards with other varieties that were badly infested for several years, never developed more than a slight infestation. In the treatment of this pest we are using 20 per cent kerosene in mechanical mixture with water on orchard trees with satisfactory results, and hydrocyanic-acid gas applied to nursery stock.

Last February and March the writer made extensive experiments with the use of crude petroleum as a remedy for this scale, proving that 25 per cent of the crude oil gives even more satisfactory results than the refined kerosene. The scales were killed when the substance was thoroughly applied and no damage resulted to the trees (peaches and plums). The pure crude petroleum killed peach trees, while 50 per cent and less did no damage.

(2) *Aspidiotus forbesi* Johnson.

This scale insect is generally distributed over the State, particularly throughout middle and south Georgia. There is hardly a bearing peach or plum orchard in the State entirely free from it and in a num-

ber of cases it has caused serious damage. It occurs on peach, plum, apple, pear, *Robinia pseudacaciæ*, and "Climbing Jasmine."

Whale-oil soap at the rate of 1 pound to 1 gallon of water, and 20 per cent kerosene, as winter washes are the remedies generally used.

(3) *Aspidiotus ancylus* Putn.

Quite generally distributed over the State on apple, oak, osage orange, *Gleditschia triacanthos*, *Ulmus americana*, and *Populus tremuloides*, but never occurs in perceptibly injurious numbers.

(4) *Aspidiotus osborni* Newell & Ckll.

Taken on *Quercus aquatica* at Atlanta, Fort Valley, Marshallville, Tifton, and Poulan, Ga.

According to Mr. Marlatt (in litt.) the distinctness of this species from *A. ancylus* is doubtful.

(5) *Aspidiotus juglans-regiæ* Comst.

Occurs very abundantly in extreme south Georgia, but rarely in middle Georgia, on peach, plum, and prickly ash. In a few instances it has been seriously injurious, necessitating treatment.

(6) *Aspidiotus hederæ* Vall.

This species occurs in south Georgia, badly infesting China trees and oleander, and is a common pest in most of the greenhouses of the State; on palms, *Cycas revoluta*, *Jasminium grandiflora*, and orange. The treatment generally adopted by florists is lemon-oil wash.

(7) *Aspidiotus ficus* Ashm.

This is a bad pest in most of the greenhouses in the State, on palms, *Cycas revoluta*, and ferns. The writer has made extensive experiments at Augusta and Marshallville on the use of hydrocyanic-acid gas as a remedy for greenhouse pests, with the result that *A. ficus* and other greenhouse insects were destroyed by the gas. No injury resulted to the common run of greenhouse plants where the remedy was properly applied.

(8) *Aspidiotus cydoniæ* Comstock.

Found in a greenhouse at Savannah on *Cycas revoluta*.

(9) *Aspidiotus uræ* Comst.

This species is common in Atlanta on the sycamores used for shade trees. According to Mr. Marlatt, who identified the specimens, it has not hitherto been known to occur on this food plant.

(10) *Aspidiotus tenebricosus* Comst.

As a rule the maple shade trees all over the State are infested with this scale insect. The damage to these shade trees in the cities is great, finally causing their death.

(11) *Aspidiotus obscurus* Comst.

This is a very abundant species widely distributed over the State on oaks. It is quite injurious to the oak shade trees in the cities and also occurs on oaks in the forests, and on hickory at Macon, Ga.

(12) *Aspidiotus camelliae* Sign.

Found at Augusta, Thomasville, and Okapilco, Ga., on peach, grape, heliotrope, Arbor-vitæ, and *Chilopsis linearis*.

(13) *Diaspis amygdali* Tryon.

This species occurs at Irby, Ashburn, Thomasville, and Bainbridge, Ga., on peaches and plums, and on lilac at Ashburn. It ranks next to the San Jose scale in economic importance when once it becomes established in an orchard. On October 6, 1898, the writer found this scale infesting an orchard of 25,000 peach trees at Irby, Ga.: 10,000 of these trees were fairly encrusted and in a dying condition. Being beyond the hope of recovery, they were dug up. The insects had spread to an adjoining orchard of 12,000 trees, where they were doing immense damage. The case at Ashburn involved about 1,000 trees, all of which were destroyed by this pest.

In 1898 the writer observed that the first brood began to issue the 12th of March, and by the 1st of April the young were about all hatched. As a remedy we use kerosene in mechanical mixture with water at the rate of 20 per cent applied in the fall after the foliage is shed from the trees, or 10 per cent applied in the spring immediately after the first brood has issued.

(14) *Diaspis cacti* Comst.

Occurs on cactus and pineapple in several greenhouses in south Georgia.

(15) *Aulacaspis rosæ* Bouché.

This is a common pest quite well distributed over the State on cultivated and wild roses, *Rubus occidentalis* and *Rubus villosus*.

(16) *Parlatoria pergandei* Comst.

The writer has collected this species at Cairo, Ga., on dwarf orange, and at Savannah, Ga., on *Maranta massangeana*.

(17) *Parlatoria zizyphus* Lucas.

Found on lemons from Italy exposed for sale in Atlanta and Carrollton, Ga.

(18) *Mytilaspis pomorum* Bouché.

Generally distributed over the State on apple, peach, and plum. It has proved very injurious in a few cases.

(19) *Mytilaspis gloverii* Pack.

Found at Marshallville, Ga., on orange in a greenhouse, and on *Magnolia fuscata*.

(20) *Mytilaspis citricola* Pack.

Found on dwarf orange in a greenhouse at Thomasville, Ga. It is also common on oranges from Florida exposed for sale in Atlanta, Ga.

(21) *Chionaspis furfura* Fitch.

This species has been found at Fort Valley, Marshallville, Albany, and Thomson, Ga.: on peach, plum, and apple. In the Marshallville

section it is surprisingly destructive. On April 13, 1900, the writer examined an orchard of 2,000 Robinson plums in that section that was thoroughly infested with this scale. Scarcely a tree could be found that was free from it, and most of them were encrusted from the ground to the tips of the twigs. Branches that had been killed by the scale the previous fall still retained their old leaves.

At the above date the young had apparently been hatched for several days. They covered the branches and the white filamentous wax exuded by the larvæ was profuse. No effort was made to save the trees and they were dug up; however, not before the scale had spread to an adjoining peach orchard, which became badly infested.

(22) *Chionaspis euonymi* Comst.

Found severely infesting a hedge of euonymus at Decatur, Ga. It became so injurious that the hedge was destroyed.

(23) *Chionaspis americana* Johnson.

This species is quite injurious to *Ulmus americana*, used as shade trees in Atlanta, Augusta, and Americus, Ga., and undoubtedly occurs in many other cities of the State.

(24) *Chionaspis nyssæ* Comst.

Found in great abundance on *Nyssa sylvatica* in a forest near Powder Springs, Ga. The females were confined to the trunk and branches, while the males were principally upon the leaves.

(25) *Ischnaspis longirostris* Sign.

On *Kentia belmoriana* in a greenhouse at Atlanta, Ga.

(26) *Fiorinia floriniæ* Targ.

Found in greenhouses at Thomasville and Augusta, Ga., on *Camellia japonica* and *Cycas revoluta*.

(27) *Pulvinaria immanabilis* Rath.

Occurs sparsely on oak, elm, and sycamore at Atlanta, Austell, and Tifton, Ga.

(28) *Pulvinaria acericola* W. & R.

On June 1, 1900, the writer examined two maple shade trees (*Acer dasycarpum* ?) in Atlanta that were thoroughly infested with this species. They were crowded on the branches, while the leaves were not so badly infested. At the date named a considerable per cent of the females had extruded their ovisacs, and, peculiarly enough, the majority of them did not migrate to the leaves. This species also occurs abundantly on *Acer pennsylvanicum* in Atlanta.

(29) *Pulvinaria amygdali* Ckll.

This coccid occurs in injurious numbers on plums at Albany, Pine City, Marshallville, and Fort Valley, Ga. It also occurs on apples at Albany, Ga.

(30) *Pulvinaria macluræ* Kennicott in Fitch.

Found on osage orange in Atlanta, Ga.

(31) *Lecanium nigrofasciatum* Pergande.

This is a common pest in south and middle Georgia, but rarely occurs in north Georgia. It spasmodically occurs in injurious numbers and is particularly abundant this season. Some large orchards in the Fort Valley section are now suffering severely from the attacks of this pest.

(32) *Lecanium hemisphaericum* Targ.

A common pest in most of the greenhouses of the State on ferns, palms, orange, and oleander.

(33) *Lecanium hesperidum* Linn.

Very common in several localities of the State, both in greenhouses and outside, on palms, ferns, *Phlox drummondii*, and *Vinca variagata*.

(34) *Lecanium tessellatum* Sign.

Found on *Caryota urens* in the greenhouses at Augusta and Savannah, Ga.

(35) *Lecanium longulum* Dougl.

Very abundant on roses in a greenhouse at Savannah, Ga.

(36) *Lecanium tulipiferae* Cook.

An injurious species on *Magnolia fuscata* at Thomasville and Andersonville, Ga.

(37) *Lecanium armeniacum* Craw.

This species occurs very abundantly on water oak in many localities of the State, and is occasionally found on plums.

(38) *Ceroplastes cerripediiformis* Comst.

Taken at Thomasville and Valdosta, Ga., on quince and *Eupatorium*.

(39) *Lecaniodiaspis tessellatus* Ckll.

This coccid occurs in great numbers on native persimmons at Marcus, Eatonton, Hamilton, and Macon, Ga.

(40) *Kermes trinotatus* Bogue MS.

The writer first collected this species on *Quercus aquatica* at Atlanta, Ga., August 21, 1899. Later, Professor Quaintance and he collected it in quantity at Tifton, Ga. Specimens were submitted to Professor Bogue, and he has described it under the above name to be published in the Canadian Entomologist. (Bogue in litt.)

(41) *Kermes* n. sp.

This species was collected by the writer on *Quercus stellata* at Atlanta, Ga., May 26, 1900, and later found at Griffin and Coleman, Ga., on the same species of oak. It occurs on the twigs and on the midrib and veins of the leaf. Specimens were submitted to Professor Bogue, who has pronounced it a new species.

CONCLUSION.

The writer in person has collected all of the 41 species recorded in this paper, besides which he has collected 7 species not yet determined, viz, two of the genus *Aspidiotus*, one each of the genera *Chionaspis*, *Diaspis*, *Pulvinaria*, *Dactylopius*, and *Eriococcus*.

The writer is greatly indebted to Mr. L. O. Howard and his assistants, Messrs. Marlatt and Pergande; also Professors Bogue, Cooley, and King, all of whom took part in the study and identification of the Coccidæ recorded in this paper.

In discussing this paper Mr. Fernald stated that he deemed it worthy of mention that *Diaspis amygdali* has now been reported from five places in Massachusetts, all near Boston, all upon trees used for shrubbery or ornamental trees of various kinds, and that in each case it has been traced to plants bought of a nursery importing direct from Japan. It does not seem to spread rapidly from tree to tree or plant to plant, but it is nevertheless very effectual in crushing out the life of the plant it is on, and has survived very severe weather.

Mr. Kirkland said there was no doubt about the nursery in question, as he had been there once or twice and had seen shipments just unpacked from Japan which were infested with *D. amygdali*.

Adjourned until 9 a. m., June 23.

MORNING SESSION, JUNE 23.

The Association met in joint session with the Society for the Promotion of Agricultural Science, the chair being occupied by President Beal, of the latter society.

PRESIDENTIAL ADDRESS.

[Withdrawn for publication elsewhere.]

The first paper read was the annual address of President Beal, which will be published in the proceedings of the Society for the Promotion of Agricultural Science.

Mr. Howard read the next paper, entitled:

PROGRESS IN ECONOMIC ENTOMOLOGY IN THE UNITED STATES.

By L. O. HOWARD.

[Printed in the Yearbook of the Department of Agriculture for 1899.]

The next paper, by Mr. Gillette, was entitled:

APIARY NOTES.

By CLARENCE P. GILLETTE, Fort Collins, Colo.

[Withdrawn for publication elsewhere.]

The next paper was entitled:

NOTES UPON THE DESTRUCTIVE GREEN PEA LOUSE (NECTAROPHORA DESTRUCTOR JOHNS.) FOR 1900.

By W. G. JOHNSON, *College Park, Md.*

Perhaps no insect in recent years has attracted more attention than the destructive green pea louse. It became conspicuous, first, on account of its ravenous attacks upon pea fields, a crop heretofore practically immune from the ravages of insects; and, secondly, from the fact that it was a species not recorded in science. What condition in nature was responsible for such a general distribution of a new species of insect the writer will not attempt to discuss in this short paper. It appeared last year, and was recorded for the first time, from Maine along the Atlantic coast southward to North Carolina, and westward to Wooster, Ohio. It was also observed in Nova Scotia and Ottawa, Canada. I had it sent to me from Massachusetts and Vermont in July and August, and complaints of its serious nature have come to me from Chillicothe, Ohio, Long Island, N. Y., portions of New Jersey, and Wisconsin (August). I first observed the pest May 18, 1899, and have had it under constant observation from that date to the present writing. I described the newcomer in the February issue of the Canadian Entomologist as *Nectarophora destructor*. A very long name, I admit, but if there is anything in a name being a burden to its possessor, we hope that this one will accomplish such a purpose.

From the first I have held that this insect is probably a clover pest. It has been observed upon both red and crimson clover, and this season hundreds of acres of red clover have been destroyed by it. In one instance, reported to me June 13, Mr. C. Silas Thomas, of Lander, Frederick County, Md., stated that the pest had almost entirely ruined 65 acres of red clover for him. Many other cases of a similar nature were reported or observed by us. The attack has been very common upon crimson clover also, but I have not heard of a field being killed by it. That clover, and perhaps the red clover, is its original food plant seems quite conclusive from our experiments and observations. I am of the opinion that red clover is its original food, and that it is, therefore, primarily a clover pest. Without doubt it is a native American insect, and has spread its attacks to crimson clover and field peas, as these two plants have encroached upon the feeding ground of the louse. It spends the winter, at least in the South, as an adult in clover fields. It may winter in another form farther north.

It is barely possible that this insect has other food plants and lives over winter upon them, but clover is, no doubt, the main plant upon which it lives. Mr. F. H. Chittenden, of the U. S. Department of Agriculture, Division of Entomology, in Washington, observed this

insect, or one very closely allied to it, feeding upon a number of species of vetches in Washington this year. From a long series of experiments here in the laboratory we have shown that there are two kinds of females known at present, the winged and wingless forms. No male has as yet been discovered, and perhaps in the South none exists, and the insect remains over winter in the adult stage, as stated above, upon some plant, and in most instances this is clover. The female produces living young which reach maturity in from ten to fifteen days, and possibly less time in hot weather. As an example, a young one born March 4 reached maturity (winged form) March 16, or twelve days from time of birth, and was producing living young on March 19. From March 19 to April 17 it became the mother of 111 young, and died on the latter date. Her first young (wingless form), born March 19, reached maturity and was producing on March 31, or eleven days from time of birth. From March 31 to April 13 she gave birth to 120 young and died. We have made many other observations of a similar character, but this will suffice to show the rapid reproductive powers of this insect, and we might state that in many instances where this insect was first observed May 1, three weeks later the fields were abandoned on account of its attacks. Calculating from the average number of insects produced per day (which is 6) in six weeks one would become the progenitor of 423,912.

It was estimated last year that the total loss from the attacks of this creature along the Atlantic coast States was \$3,000,000, and that the crop was estimated at only one-half the usual output. From close communion with the largest growers, the most experienced seedsmen, and most extensive business men in this line of business, The Trade, a canned-goods journal published in Baltimore, has gathered the information that the crop of peas of the Atlantic coast this year will not exceed, on the outside, one-third of what it was last year. This is about as serious as it can be, when it is taken into account that it is mostly due to this one pest, and that it is certain to increase its destructive powers from year to year, unless some factor in nature intervenes to check and retard its further development. With this condition of affairs it is not strange that farmers have become thoroughly discouraged, and make the statement that they will be more cautious about planting peas for market purposes or for the packer in the future. With this year's experience, however, we have shown conclusively in our experiments and practical work in the field that this insect can be kept in control to a very great extent if taken in hand in time. In the first place, the peas must be planted in rows 24 or 30 inches apart, as shown in the illustration (Pl. I, fig. 1), and not broadcast or in drills, as has been the case over a wide area throughout many of the Southern States. As an illustration of this we might cite an instance on the place of Mr. C. H. Pearson, a large packer of Balti-



FIG. 1.—SPRAYING PEAS WITH TOBACCO-WHALE-OIL SOAP, SHOWING METHOD OF PREPARATION AND APPLICATION.

(Author's photograph.)



FIG. 2.—SECTION OF A 600-ACRE PEA FIELD, ROWS ONE MILE LONG, SHOWING SPRAYING OUTFIT READY FOR WORK.
PEAS FINALLY SAVED BY BRUSH-AND-CULTIVATOR METHOD

(Author's photograph.)



FIG. 1.—FIELD OF PEAS SAVED BY BRUSH-AND-CULTIVATOR METHOD, SHOWING IMPLEMENTS USED.

(Author's photograph.)



FIG. 2.—FIELD OF PEAS SAVED BY THE BRUSH-AND-PAN METHOD, SHOWING THE APPARATUS USED.

(Author's photograph.)

more. His 600-acre pea plantation was practically saved by persistent and energetic efforts on his part this season. All the methods from a practical standpoint were tried on this place, and it was found that the brush and cultivator method (see illustration, Pl. II, fig. 1) was the most effective. Forty men were therefore engaged to work in the field, and the 600 acres were brushed and cultivated every third day for a period of two weeks, and in this manner the entire field was saved, netting the owner from 25,000 to 30,000 cases of peas of 2 dozen each. It is a fact which is not questioned by those who are familiar with this plantation that had not this persistent and energetic fight been followed, the greater portion of the peas would have been destroyed by the insect. Last year the peas over the same area were broadcast, so there was no opportunity of fighting the pest, and as a consequence 480 acres were entirely ruined by it, as reported last year before this Association (Bul. No. 20, n. s., Div. Ent., U. S. Dept. Agr., p. 94). This year, by changing the method, and by a new system of fighting the pest, the peas have been saved. Many other illustrations of a similar nature could be given where we have been following this method persistently in this State.

The brush and cultivator method is a simple one, and the implements for this method are shown in the accompanying illustration, Pl. II, fig. 2, which represents a field of peas which was saved by brushing and cultivating. We might state, however, that a field not far distant from the one shown in the figure, where nothing was done, was totally ruined by the pest. A good pine switch is used to brush the vines backward and forward ahead of the Iron Age cultivator, drawn by one horse, and in this manner the insects are covered and a very large proportion of them destroyed. The cultivation should not be repeated until the third day, as it requires usually something over forty-eight hours for the destruction of the adult insects when covered with earth. On this plantation we also sprayed a large acreage to show the practical side of this work, and the outfit just ready to begin work is shown in Pl. I, fig. 2. Suffice it to say that we have found that no spray can be used which can destroy a percentage of insects large enough to warrant the expense of the operation. In this instance we sprayed 100 acres in two days, and thoroughly tested the method from every standpoint, using various materials. We abandoned the spraying apparatus, and began the brush and cultivator method, which was followed up persistently, with the results already noted. We have also used the "brush and pan," as shown in the illustration (Pl. II, fig. 2), in which instance a bushel of lice were caught to each row, 125 rods long.

Many natural enemies, such as parasitic and predaceous insects, have been found feeding upon this pest in the fields, and in this manner, no doubt, the number has been somewhat reduced. The most important factor, however, we have observed in the destruction of this pest has

been the fungous disease, *Empusa aphidis*, which was common the early part of the season upon this insect, in both clover and pea fields. It is a contagious disease, and destroys the pest in very large numbers, under certain conditions. In one instance we found 58 dead lice upon the under surface of a single lobe of a clover leaf, and it was not an uncommon thing in June to find 15 or 20 dead lice upon the under surface of a pea leaf. With the rains which prevailed throughout this section during June, which fostered the development of this disease, it spread rapidly throughout the infested fields, and as a consequence it was very difficult to find the pea louse upon late peas. A careful examination of peas where the insects were abundant in June showed that they were practically free from them. We feel, therefore, that the climax, as far as the development of the insect this season, has been reached, and that these silent factors in nature are now actually reducing the pest to such a point that it may possibly be several years before it will be such a destructive pest in this section as it has been for the past two seasons. At any rate, the conditions are such that the farmer and canner have taken new hope, and we trust the future will bring fewer lice and more peas.

In discussing this paper Mr. Hopkins said it would be interesting to know whether it is possible for this to be an introduced pest, and asked Mr. Johnson whether he had made any investigations in that respect.

Mr. Johnson replied that his opinion is that it is not an introduced pest but an indigenous insect, and that the change of conditions has brought about this enormous development in numbers.

Mr. Hopkins asked if there are any records of its previous occurrence in great numbers.

Mr. Johnson stated that the only record he has is one by Mr. Beckwith, formerly of the Delaware station, made ten or twelve years ago, and the record of its occurrence along the Potomac River in 1887. In neither case however, are we sure that it is the same insect, as specimens are not available. The growers of Maryland, Delaware, and Virginia state now that this insect has been known to them for a number of years.

Mr. Hopkins said this case is such a complete parallel to the invasion of the pine-bark beetle, which has been fully presented and published and the trouble from which is now over, that it occurred to him that in this case within the next few years this insect will probably disappear or become exceedingly rare. He had taken the trouble, in connection with the investigation of the pine insect, to look up the history of invasions by indigenous insects and found that they multiply rapidly for several years, become enormously destructive, and a

few years later disappear. They are destroyed by parasites or by climatic conditions and soon become rare species. This happened in the case of the pine insect, which was scarcely heard of before, and was one of the rarest insects in collections until it suddenly occurred in 1891 in such enormous numbers as to destroy millions of dollars worth of timber, but now it is practically extinct. Not a single living specimen has been found since the fall of 1892. Professor Johnson's paper shows the great importance of the work he has undertaken, and his experience will be of inestimable value in dealing with future outbreaks of the pea louse. He thought the farmers of Maryland would make a great mistake by changing their locations for growing peas until perhaps a year has elapsed, because if the rule follows in regard to sudden invasions by indigenous insects they will soon disappear or become rare.

Mr. Johnson said he was greatly obliged to Mr. Hopkins for his opinion, but there is so much money at stake that the growers could not let the matter rest awaiting nature's relief. He believed fungous diseases, especially *Empusa aphidis*, is one of the factors which will bring about the temporary disappearance of the pest.

Mr. Galloway said the point in regard to the appearance and disappearance of forms holds good in fungous attacks also, the most striking example being the potato blight. The same holds good in the passing of the Russian thistle. These things come and go and come again, and the principle holds good with fungous diseases as well as with insects.

The next paper, by Mr. Galloway, was entitled:

PROGRESS IN THE TREATMENT OF PLANT DISEASES IN THE UNITED STATES.

By B. T. GALLOWAY, *Washington, D. C.*

[Printed in the Yearbook of the Department of Agriculture for 1900.]

The next paper, by Mr. Webster, was entitled:

METEOROLOGICAL INFLUENCES ON THE HESSIAN FLY.

By F. M. WEBSTER, *Wooster, Ohio.*

[Withdrawn for publication elsewhere.]

The meeting then adjourned to Central Park to inspect Mr. Southwick's spraying outfit.

AFTERNOON SESSION, JUNE 23.

Owing to the large number of papers to be read, it was resolved that each author be allowed ten minutes in which to present an abstract of his paper, and that all discussions be postponed until the papers had been presented.

The following papers were then presented:

HYDROCYANIC-ACID GAS AS AN INSECTICIDE ON LOW-GROWING PLANTS.

By E. DWIGHT SANDERSON and C. L. PENNY, *Newark, Del.*

The desirability of using a gas as an insecticide upon low-growing plants, more especially for plant lice, but also for some leaf folders and other insects which can not be reached by means of a spray, has long been apparent to entomologists.

So far as known the only work previously done upon this problem is that of Prof. H. Garman, who seems to have been the first to suggest such use of a gas, with carbon bisulphide upon the melon louse, mentioned at the meeting of this society in 1893, and his subsequent experiments with hydrocyanic-acid gas in 1894 (Bul. 53, Ky. Agr. Exp. Sta.), and the further experiments of Dr. J. B. Smith with carbon bisulphide upon the same insect in 1895 (Bul. 109, N. J. Agr. Exp. Sta.). It is believed that neither of these gentlemen, however, have perfected practical apparatus, nor outlined a method for its extensive use in the field.

Two years ago, under the direction of Prof. W. G. Johnson, we did considerable work with hydrocyanic-acid gas in tents and box frames over trees, and in boxes for nursery stock, in combating the San Jose scale. In one instance several hundred young trees were fumigated with flour barrels. Young apple trees were also fumigated for plant lice with marked success. Having read the experiments by Professors Garman and Smith, this experience with the gas led me to attempt the problem of applying it to use upon low-growing plants during the past spring.

Carbon bisulphide has not been tried, as the trials already made, including also some recently recorded by Professor Webster, showed that it was very much slower in its action, a serious obstacle to its extensive use. This point might indeed be overcome by using a larger number of coverings, but a large investment in apparatus would preclude its use in many instances. Where carbon bisulphide requires an hour to kill plant lice, hydrocyanic-acid gas takes but ten minutes. Thus in use upon melons, with a cover for each plant, with 100 covers hardly more than 1,000 plants could be fumigated in a day with carbon bisulphide, while five or six times as many could be treated with hydrocyanic-acid gas. As regards cost of chemicals there is not much difference, though, if anything, carbon bisulphide is slightly more expensive. Both gases are dangerous poisons, but, all things considered, I believe that hydrocyanic-acid gas is possibly preferable to carbon bisulphide in this respect. There is but little danger with hydrocyanic-acid gas in such small quantities in the open air, the greatest danger being in

handling the salt solution, and though CS_2 is not as poisonous, it is highly explosive.

For fumigating individual plants the apparatus needed and method of generating the gas was soon ascertained. For small melon and cabbage plants we had made small paper covers, under which the gas is generated. These are pyramidal in shape, the apex being 8 inches high, and the paper fastened to the inside of a wood frame 3 inches high by 20 inches square, which forms the bottom. This frame is sharply beveled on the lower edge, to enable one to firmly plant the cover in the soil. A good quality of building paper is used for the top and is cut in one piece, so that there is only one seam. The materials for these covers cost from 3 to 4 cents, and we are having fifty made for \$6. In the field the covers are easily handled, as they rest one within the other.

We have found that in using potassium cyanide a small amount in solution is much superior to the dry salt, it being more easily measured and handled. Furthermore, in first mixing the acid and water and then dropping in the salt much of the heat necessary to the generation of the gas is lost by radiation before the salt can be thrown in, no matter how quickly the generation be performed. By dissolving 100 grams of KCN in sufficient water to bring the solution up to 200 cc., when finished a solution is secured which is of good strength and one of which different amounts can be easily computed, 2 cc. equaling 1 gram KCN. To generate the gas a one-fourth dram (8 cc.) vial is filled with the KCN solution and an equal or slightly less amount of sulphuric acid placed in the bottom of a 2-dram vial. The larger vial is thrust deep in the earth, being careful to place it so that the overflowing acid will not strike the plant or cover. The smaller vial holding the cyanide is then dropped into the acid, mouth down, and the plant quickly covered and the cover firmed down. The capillarity of the one-fourth dram vial prevents a too sudden generation of the gas and allows time for placing the cover. The vials are carried in carriers holding one hundred or more, as desired. These are made of a piece of board for the bottoms, in which two hundred holes the size of the vials have been drilled, on the bottom of which a piece of wire netting is tacked. With sides and a hinged cover these make handy and safe trays. No stoppers are used, but a piece of rubber packing inside the cover of the tray would serve the same purpose.

As regards the amount of cyanide to be used and the length of time necessary to kill plant lice and other insects, there has not yet been opportunity for sufficient tests to give conclusive results. From some 75 tests made, we believe that a one-fourth dram vial of the above-mentioned solution (or about four-tenths gram KCN per cubic foot air space) with an equal amount of acid for ten minutes will be found entirely satisfactory. In some tests upon young canteloupes which

were covered with water after a slight shower we found that they were badly injured by this strength, though we doubt they would have been hurt had they been dry. Possibly a less time may be sufficient, but we doubt that in handling fifty or one hundred covers it would be of much advantage, as they could hardly be changed and the gas generated in less time. The very much larger amount of gas than is necessary in a larger box or frame is due to the relatively large soil surface, and the fact that more or less necessarily leaks out around the edges at the bottom. In using these covers for such insects as melon lice it would rarely be necessary to fumigate every hill. But were every hill fumigated, with hills 5 by 5 feet, the chemicals for the treatment would cost not over 75 cents per acre, and with one hundred covers two men should be able to fumigate 3 to 5 acres a day. Upon the first opportunity we shall try this treatment with fifty or one hundred covers over an acre or two during the present season.

The fumigation of plants grown in rows is, however, more difficult, and presents some obstacles. A frame 15 feet long, with two sides slanting so that in cross-section the frame was triangular, 20 inches wide at the open bottom and 8 inches high, was first used, but it was soon found, as had been expected, that the gas would not diffuse readily in such a shaped covering.

It seemed desirable, therefore, to determine the exact manner of diffusion of the gas in such an elongated frame, and also points as regards (1) the amount of gas produced by a given amount of KCN, sulphuric acid, and water, (2) the influence of the soil and wet plants upon the strength of the gas, and (3) whether the strength of the gas deteriorates after a given time. This work was taken up by the station chemist, Mr. C. L. Penny, who has very carefully secured and analyzed samples of the gas under various conditions to determine these points. Only a mere summary of the results can now be given. During the present summer we purpose studying the manner of diffusion of the gas in a room such as nurserymen use as a fumigatorium, and later will publish a detailed account of all the experiments.

A frame covered with rawhide paper, $13\frac{1}{2}$ feet long and 18 inches square at the ends, was constructed for this work. The bottom was taken off and the frame aired after each test, and sealed with putty when replaced. The gas was generated by running the acid into the cyanide solution by means of a stopcock so that there was no possibility of loss or leakage. A known amount of gas was drawn off—after passing through a drying tube—into several large bottles, by first exhausting these with an air pump. A 36-gallon kitchen hot-water boiler was nearly exhausted of air, and a mercury gauge attached. Between this and the reservoir of bottles was placed a train of wash bottles containing nitrate of silver solution, and all were then connected. Upon opening a valve the larger tank thus drew a quantity of the gas through the wash bottles whose volume was easily determined by the mercury

gauge and whose content of gas was subsequently determined by titration. The gas was generated at the middle and either ends of the frame and samples taken from all of these and opposite points after different lengths of time. A solution of cyanide and sulphuric acid in proportion of 1 part cyanide to $1\frac{1}{2}$ parts acid to $2\frac{1}{4}$ parts water and an amount equal to two-tenths gram potassium cyanide per cubic foot air space was used in all of these tests. The amount of cyanide remaining in the residual solution was determined in each instance and deducted from the amount calculated to be present if the gas were completely generated and diffused. With this frame the residuum averaged about 5 per cent; with a large box, mentioned below, about 3 per cent, and the percentage was found to decrease the more time elapsed after generation. With the generator and intake at the same end after three minutes it was found the amount varied from 70 to 197 per cent of the calculated amount with an average of 13 per cent. In other words, the gas diffused irregularly, but remained largely in the end where generated. The generator was then placed at the middle and the intake at the end. Samples were taken after ten minutes, thirty minutes, one, four, and twelve hours. In all of these the gas was found to diffuse irregularly and in no instance was the diffusion nearly complete. As far as could be detected the frame was tight, but a loss of gas seemed to occur in some way, whether by leakage or transfusion is a question. At any rate, after twelve hours not a trace of gas was found. The average percentages of the calculated amount for the four other periods were 46, 41, 27, and 13 per cent, respectively, showing a regular decrease the longer the time, but never a complete diffusion, the highest amount after ten minutes' time being 70 per cent.

From these tests it seemed evident that by itself the gas would not diffuse evenly in such a frame. A rough fan was therefore put in the center, and a diaphragm placed horizontally through the center to within a foot of each end, so that a thorough circulation might thus be secured mechanically.

By use of this mixer with the generator and intake at opposite ends after five minutes 72.4 per cent of the calculated amount was secured, and this with fairly constant results, only varying from 68.5 to 75 per cent in four trials. As this fan was far from a perfect device, and also promoted leakage, we concluded that these tests showed fairly that in such a shaped frame the gas diffuses entirely irregularly and never completely. In other words, it would be necessary in actual usage to generate a very much larger amount of gas than necessary were it diffused, in order to secure a sufficient amount in all parts to be effective, with the danger of burning the plants at the point of generation if used too strong. Evidently the only way to determine this was by tests in the field upon insects, as such a fan arrangement was clearly impracticable.

To determine the influence of wet plants on the amount of gas, a half-bushel of leaves were sprinkled, shaken, and placed in the frame. After five minutes only 54.3 per cent of the calculated amount of gas remained, or 75 per cent of what would have been secured without the leaves. In other words, the moisture absorbed one-fourth of the gas. This influence of moisture must needs be considered in the fumigation of nursery plants packed in wet moss, or sprinkled, or in field work after a rain or heavy dew. The bottom of the frame was then removed and the gas generated over soil containing an average degree of moisture. After five minutes 45 per cent of the calculated amount was found remaining, or 62.7 per cent of what would have been secured were the box closed. Thus the soil and possible leakage, which was slight, as the soil was well banked and packed around the bottom, took up three-eighths of the gas generated. This influence of the soil upon the amount of gas is very important in the use of these frames with a large surface exposed to the soil, which, of course, decreases the ratio of the soil surface to the volume of the gas.

The diffusion of the gas in a wooden box which had been made for fumigation of nursery stock was then tested. This box is 8 by 3 by $2\frac{1}{2}$ feet, and was made of two thicknesses of matched flooring, with building paper between. The lid fitted tightly and the joint was sealed with putty. With the generator and intake at the same end, at the end of two minutes 33.7 per cent of the calculated amount was found; in ten minutes, 62.7 per cent; in twenty minutes, 56 per cent. With the generator and intake at opposite ends, however, 265 per cent was found in two minutes, 160 per cent in five minutes, 92 per cent in ten minutes, and 9.5 per cent in sixteen hours. Thus the diffusion of the gas in this shaped space is just the opposite of that in a long frame—that is, in the cubical space the gas is puffed to the opposite end at the end of two minutes, but about one-third being at the end of generation and two-thirds at the opposite end, and requiring about ten minutes for the complete diffusion, while in the long frame the gas became “banked” at the point of generation, and is never completely diffused without a mechanical agitation.

These in brief are the facts drawn from the laboratory study of the diffusion. How were they supported by experiments in the field?

It must be remembered that in the field tests a larger amount of gas would be required to compensate the influence of the soil and foliage. The triangular frame 15 feet long by 8 inches high by 18 inches wide, with a door at the center to admit the generator, was first used. It will be noticed that this frame has but about one-fourth the area in cross section of the square frame used at the laboratory, and therefore the diffusion would be at least inversely that much more difficult. With two-tenths gram KCN per cubic foot air space all lice were killed at the middle of the frame in ten minutes, the generator being

at the middle. Neither with this strength at ten, fifteen, or twenty minutes were the lice at the ends of the frame even stupefied, but with three-tenths gram KCN per cubic foot many of the lice were stupefied at the ends in ten minutes, but all soon recovered. With three-tenths gram for fifteen minutes, however, the lice half way between the middle and ends were killed.

This frame was not only too long and of too small diameter for the diffusion of the gas, but was too long to be readily handled and to accommodate itself to any unevenness of the ground. A frame 10 feet long by 10 inches high by 24 inches wide at the bottom, also of a triangular shape, was therefore made, but with doors at either end instead of one at the middle. In the tests made with it one-half of the gas was generated at either end instead of from the middle. In these frames the cyanide solution and acid can be measured and handled in larger vials, and these carried in trays, as for the small covers. A 3-dram long-style vial five-sixths full of the cyanide solution (2 cc. equals 1 gram KCN) and 8-dram short-style vial, with 2 cc. sulphuric acid in the bottom, give one-half the amounts necessary for three-tenths gram KCN per cubic foot in this 10-foot frame, one generation being made at each end of the frame. By using these vials the carrying and cleaning of a separate vessel in which to generate the gas is obviated. Using two-tenths gram KCN per cubic foot, after ten minutes five tests showed an average of 16 per cent of the aphides alive at the ends and 25 per cent alive at the middle, or that the gas was but slightly more effective at the ends than in the middle, and was insufficient to kill the lice at either point. All of these lice were stupefied and remained so for some time, but were found alive the next morning. In this connection it might be well to state that in such tests plant lice should always be kept at least for twelve hours. They have a remarkable power of "playing possum," and will often remain stupefied for three or four hours. The same dose for five minutes left 37 per cent alive at the ends and 17 per cent in the middle, showing the gas to have been more effective in the middle. This shows a similarity in the diffusion to that found in the large box used in the laboratory in that the gas was at first thrown from either end to the center and was found to be more effective in the middle than at the end after five minutes, but this became so diffused that the gas was slightly more effective at the ends after ten minutes. Three-tenths of a gram KCN per cubic foot for five minutes also failed to kill the lice. Later three-tenths and four-tenths of a gram per cubic foot were tried for ten minutes, and only in one or two instances did we find from 10 to 25 per cent alive when the former strength was used, and four-tenths of a gram killed all the lice and other insects in every test. Three-tenths of a gram for fifteen minutes would undoubtedly be effective. With none of these strengths were the strawberry plants upon which the

work was done injured. In fact, from the results of fumigating plants before setting them out, we believe that strawberry plants in the field would stand a strength of two-tenths or three-tenths of a gram KCN per cubic foot for twenty or twenty-five minutes, were that necessary.

Work done with a wooden box 2 by 2 by $2\frac{1}{2}$ feet, with open bottom, in fumigating loose strawberry plants infested with *Aphis forbesi* brought out the influence of the soil on the gas and the ready diffusion in a cubical space. In this box two-tenths gram KCN per cubic foot in ten minutes, three-tenths gram in five minutes, and one-tenth gram in twenty minutes proved fatal to the aphides.

Thus, in the 10-foot frame, with a soil surface of 20 square feet and a cubic capacity of $8\frac{1}{3}$ feet, or a ratio of $2\frac{1}{2}$ soil surface to 1 of volume, just twice as much gas was required to be generated from two points to be effective as that in the wooden box of 10 cubic feet capacity and 5 square feet soil surface, having an almost opposite ratio of 2 volume to 1 of soil surface. Again, the covers for individual plants, with a soil surface of about 3 square feet and a capacity of one-half cubic foot, or a ratio of 6 soil surface to 1 of capacity, required eight-tenths gram per cubic foot, or four times as much. Comparing these figures with the results obtained in the laboratory test of the influence of the soil, by a rough calculation a rule somewhat as follows might be deduced: Let x equal the mean height in feet: then the amount of cyanide of potassium per cubic foot expressed in decigrams would be 2 plus the reciprocal of x , or the decigrams of KCN to be used per cubic foot equals $2 + \frac{1}{x}$.

Whether these ratios would hold true for a larger series of tests remains to be ascertained, but they at least indicate the general tendency of the diffusion of the gas and the influence of the soil upon it. The cost of such frame is but little. The materials for them should not cost over 25 or 30 cents, and they are easily made. With rows 3 feet apart, using 12 frames, with three-tenths gram per cubic foot for ten minutes, an acre could be covered in about two days at a cost of about \$3 for chemicals. This treatment is practicable, therefore, only upon plants of some considerable value and for relatively small areas. Under many circumstances, however, it could be used to much better advantage than any other means of combating a pest, and often might be found effectual where no other method of extermination were possible.

NOTES FROM DELAWARE.

By E. DWIGHT SANDERSON, *Newark, Del.*

The harlequin cabbage bug.—The harlequin cabbage bug has been under observation as much as the scarcity of material would permit. Last year the bugs were not noticed till late in the summer, and injury by them, as noted in one or two instances, was confined to very late

cabbage. The present spring they have also been unusually scarce, though more abundant than last year. April 25 I found the sexes pairing on kale at Smyrna, and a few eggs already deposited. Several pairs were brought to the insectary. The mating of the sexes takes place at frequent intervals, often for the larger part of a day, during the period of a month or more. One female, with which was placed a male from May 1 to June 1, deposited fifteen clusters of eggs in that time. Another female, which mated on April 29, and was then placed alone, deposited six clusters of eggs up to May 19. The young from eggs laid May 1 became full grown June 19.

The appearance of this insect in the spring seems to be somewhat irregular. At Camden, May 12, I found but one or two stray females on some kale next to where a patch of late cabbage was fairly alive with bugs last fall, and where the same cabbage had been stored all winter. At Milford none could be found until May 29, when one or two were found here and there on the cabbage grown up to stalks, where were one or two clusters of eggs. One of our largest cabbage growers tells me that a few years ago it was almost impossible to raise cabbage on account of this insect, but that for the last few years he has used kale as a trap crop with the best of success, having very little trouble in thus catching the old bugs, and as a result of this procedure and the careful hand picking of the few that stray to the cabbage, during the last two or three years he has been troubled but very little, while his neighbors' cabbage has often been ruined.

On March 21 I received partially grown lots of *Gastrophilus equi* through our veterinarian, Dr. H. P. Eves, which, it was thought, had caused the death of a horse. The bots were taken from the stomach, which was full of them and was badly ulcerated. Dr. Eves stated that here and there the stomach and intestines had clearly been perforated by the bots, and the scars made by them were found throughout the length of the intestinal canal. A week later Dr. Eves sent me bots of *G. nasalus*, most of which were found in the esophagus of a horse.

The rose-chaffer (*Macrodactylus subspinosus*) has been much less numerous than usual this year, as has the plum curculio (*Conotrachelus nenuphar*). In fact, but few of our fruit growers have resorted to "bugging," as they term hand picking and jarring.

Apples are being largely planted in Delaware, and the insects affecting them have been quite an annoyance, especially on young trees top worked by budding.

Aphis mali Fab. attacks the buds as soon as they commence to swell in the spring and often seriously stunts their growth or kills them. The eggs of this species commenced hatching on April 15, and the last hatched about May 7. These became less numerous late in May and had nearly disappeared by the middle of June, being largely destroyed

by larvæ of *Syrphus americanus* and parasites, among which is *Lysiphlebus myzi* Ashm. At several points the eggs of this aphid were very abundant, but few lice appeared and did but little damage.

Myzus sp. ?—During the last week in April the stem mothers of an aphid, determined by Mr. Th. Pergande to be a species of *Myzus*, were found depositing young with *A. mali*. These stem mothers were large, globular, bluish-black, slightly pruinose, and the young were of a light-brown color. This species curls the leaves much worse than the former, and has been found very common on apples throughout the State. On June 16 I found that they had been destroyed in one badly infested orchard mostly by parasites, among which were *Lysiphlebus cucurbitaphidis* Ashm., and some undetermined species, and also by syrphid larvæ and *Chilocorus bicoloratus*. The adults of the next generation are of a brown color, marked with yellowish where the embryos show through the abdomens. The larvæ, pupæ, and nearly molted adult apterous forms of the next generation are of a decided pinkish color, while the winged individuals are of a brownish-black color. The following generation is also partly composed of winged aphides.

Aphis sp.—Late in May an undetermined species of *Aphis* spreads to the apples from wild-cherry trees and soon becomes thickly clustered upon the terminals. This species is bright yellowish and green, prominently marked with black.

Lophoderus quadrifasciana Fern.—As the buds commenced to unfold in April, fine silk threads could be seen running here and there between the terminals. These were found to be made by small, yellow Tortricid larvæ, evidently just hatched from the eggs. Later these became a bright green color, and when full grown were about 10 mm. long. They pupated May 16 and emerged May 25 to June 2, the species proving to be *Lophoderus quadrifasciana* Fern., one not previously noted as an apple insect. The larvæ were quite common, and did more or less damage by webbing the leaves together.

The larvæ of *Penthina chionesema* Zell. have similar habits and have previously been noted as apple pests in Missouri by Miss Murtfeldt. The larvæ are so similar to the latter species that they were not distinguished, though I find subsequently that they are considered larger. A larva of this species pupated May 14 and the moth emerged May 22.

Larvæ of *Cacocia rosaceana* Harr., are common, but not sufficiently so to do much injury. Moths emerged May 30.

Cases of *Mineola indiginella* Zell. were found very common during the winter, but I did not observe much work of the larvæ in the spring. They pupated about May 15 and the moths emerged the first week in June.

A small, reddish larva was observed to do considerable damage by boring into the young buds, but I failed to rear it. Mr. Busck thinks

the larvæ may be a species of *Depressaria*, and I now have larvæ which I think are the second brood of the same species. This species was parasitized by *Microdus gibbosus* Say.

Tinetocera ocellata has not been observed, though it has sometimes been injurious in Delaware.

Steganoptycha sp.—During the latter part of last summer the terminals of young apple trees were very generally injured by a small, reddish larva boring into them. These larvæ became full grown late in October and then hibernated in their burrows in the terminals, usually at the base of a leaf petiole which remained attached over winter. In some cases the burrows were slightly lined with silk. The hibernating larvæ became somewhat flattened and reduced in size and of a lighter color. Were a twig broken open the larvæ would close the opening with silk and chips, and one or two spun whole cases of silk upon the outside of the twig when thus molested. I also found a similar case on a branch of one tree. Fully 50 per cent of the larvæ in the orchard under observation were parasitized by *Bracon mellitor* Say, whose larva makes a white, parchment-like cocoon of silk within the burrow. All terminals containing parasitized larvæ were found to be punctured by a small hole just below the cocoon of the parasite. Whether this was caused by the oviposition of the parasite or is for its exit I do not know. These larvæ pupated May 5 to 7 and the moths emerged May 16 to 23. They have been determined by Mr. Busck to be the same as *Steganoptycha salicicolana* Clem. of the U. S. National Museum collection, but he states that these specimens are probably wrongly determined. The species is doubtless the same as that found by Miss Murtfeldt in Missouri, which she describes as *S. pyricolana* Riley MSS., stating that Dr. Fernald considered it identical with *S. salicicolana* Clem. As the larvæ of the latter species, however, have been recorded as breeding in willow galls, it seems hardly probable that they are the same, and Dr. Riley, who Miss Murtfeldt states had types of Clemens' species, pronounced them distinct. The moths are very pretty little insects of a gray-brown color, with bluish reflections, and marked with bands of silvery, lead gray, and black scales. This species is very common throughout the State and has done considerable injury in some instances. *S. salicicolana* Clem. was originally from Dr. Walsh in Illinois, and I find no other mention of it except by Miss Murtfeldt.

The destructive green pea louse.—A considerable portion of the last two months has been devoted to a field study of the pea louse, *Nectarophora destructor* Johns.

Last year I found the lice still breeding on peas at the station on December 1. The first to be observed this year were seen on May 1, when, after considerable search, I found a few full-grown wingless females on early peas at Milford. On May 11 the lice were found to

be very abundant upon crimson clover throughout the State. In several instances they were observed spreading to the peas. With rare exceptions, however, they spread only to the late peas, and almost all our growers had first-class crops of early peas. One or two fields of crimson clover immediately next to pea fields were fairly alive with lice, and though none could be found on the early peas they were spreading on to the late varieties. At this time but few lice could be found on red clover. By May 22 the lice had become quite thick on the late peas. Fields sowed in 8-inch drills were found to be much worse infested than those in 30-inch rows, and subsequently were much worse injured. In fact, both early and late peas sown in drills or broadcast were a practical failure. One acre of market garden I saw had hardly a pod formed; on another field of 20 acres of Alaska and Admiral about 1,000 pounds of peas were secured and the rest was cut for fodder or turned under. By this time (May 22) most of the clover had been turned under, and the lice had left that which remained standing. They now became more common on red clover throughout the State, but never very numerous. In fact, pea lice could now be found everywhere and on everything. On squash vines, apple trees, in every fence-corner cobweb, could be found the ever-present, stray pea louse.

Not until the first week in June did the enemies of the lice commence to check their increase, and though they soon multiplied so rapidly, and did such efficient service, that but few lice were to be found when the late crop was being cut on June 18, still they were too late to benefit the pea crop, as the injury had already been done. As a result the late varieties have probably yielded about one-fourth of a crop on the average, the yield varying from absolutely nothing to a full crop. The lice have been fewer in numbers and have done less injury than last year, as last year considerable injury was done the early crop. Had it not been for the cool, wet weather of the latter part of May, the injury would have been much more severe, but this doubtless prevented a more rapid reproduction of the aphides.

Possibly the most important enemy of the lice was the fungus *Empusa aphidis*. Individuals killed by this were found commonly on clover early in the season, but not in any number. Not until June 11 were diseased lice found in quantity, but on that date it was apparent that the fungus would soon kill the larger part of them, as many were dead and the majority were affected. A week later but very few lice were found, and almost all were diseased.

Parasitized aphides were fairly common on the crimson clover, but none were seen on peas until June 11. At least 5 per cent were killed by parasites whose identity has not yet been determined. Last fall several *Aphidius washingtonensis* Ashm. were bred.

Syrphus flies were not abundant until May 30, when they were very common and ovipositing. Nine-tenths of them were *Syrphus americana* Wied., and the remainder *Sphærophoria cylindrica* Say, and *Allograpta obliqua*. *Bassus latotorius* Fab. was also quite common, and later almost all of the puparia of *A. obliqua* were found parasitized and the parasites bred from them. On June 11 no syrphus flies were seen, but on the 18th a third brood had appeared and were swarming over the field, a half dozen being seen often on a couple of feet of vines, and making a very audible buzz over the whole field.

Ladybird beetles and larvæ were common throughout May, but not until the second week of June did they become abundant. I could not determine any regularity of the broods of these insects. *Coccinella 9-notata*, *Hippodamia convergens*, *H. glacialis*, *Megilla maculata*, *C. sanguinea*, and *Adalia bipunctata* were all common, the first named being the most common. Though the larvæ of these ate large numbers of pea lice between June 1 and 18, they were too late to prevent the worst injury. *Chrysopa oculata* was common, but was not nearly as valuable as the other predaceous insects. Altogether, the enemies of the lice appear too late to prevent the bulk of the injury, and as the same was true last year, it seems impossible to place any dependence upon them. It seems evident, however, that the lice are attacked by a parasite while still in crimson clover (parasitized lice were also common on red clover), but are not parasitized until they have been on peas for some time. Is it not possible the sudden appearance of the lice last year may have been due to the severe winter, which killed off the parasites and other enemies which usually hold the lice in check on the clover and so reduce their numbers that but few of them spread to peas?

The very sudden appearance of this new species last year was a unique entomological surprise. Where it came from was a question. It would seem to me that the original food plant of the pest was clover and probably crimson clover. It is true that crimson clover is not grown in the North where the louse was found destructive last year, but it is entirely possible that it may have spread from sections in which crimson clover is grown to red clover in these localities, but have been held in check by its parasites, and remained unnoticed. Furthermore, the insect enemies of red clover have at various times received study without this species having been previously noted. On the other hand, there seems to be good evidence that the louse has been on crimson clover for several years. One of our best farmers, Mr. Frank Bancroft, of Camden, Del., tells me that he has seen what he judges to be the same louse on crimson clover for at least six or seven years. In 1890 crimson clover grown upon an experimental plot at the Delaware Station became so badly infested with a plant louse that it was feared it

would be killed. Professor Beckwith's notes state (May 11, 1890) that these were exterminated by a fungous disease, and the clover was not seriously injured. Upon looking over the station collection I found specimens of *N. destructor* which unfortunately were without any label, but were among material which was unquestionably collected prior to 1896. Upon corresponding with Professor Beckwith he informed me that he distinctly remembered preserving specimens of the aphid in question. As his accession catalogue shows no such specimens to have been numbered, though by no means conclusive, the evidence is at least strongly circumstantial that *Nectarophora destructor* occurred in injurious numbers on crimson clover as early as 1890.

As regards remedies, I have practically nothing new to offer. It evidently is important to plant crimson clover as far from peas as possible, and to turn it under as early as practicable.

Brushing, followed by harrowing, was not practiced by our growers, as frequent rains made the soil too damp to make it efficient. Brushing into pans drawn between the rows did not commend itself to the growers, though it seems to me entirely practicable and I hope to see the method in use next year.

While the lice were still confined to the terminals of the late peas, it seemed probable that most of them could be killed by a spray. An attachment fitted from one-half inch gas pipe was readily and cheaply constructed so that five rows of peas could be sprayed at once. This was used with a kero-water pump and Vermorel nozzles, and gave a good spray, which covered the plants very thoroughly. Fifteen per cent kero water was found to evaporate so rapidly in the hot sun that it failed to be effective. Twenty-five per cent killed the lice and reached a large majority of them, but I feared it would injure the vines. Though they were well saturated and looked rather sick for a day or two, however, they were not permanently injured or affected. With 15 per cent kerosene an acre was sprayed twice with 5 gallons of kerosene and 2 barrels of water. One spraying with 25 per cent was much more effective and would be no more expensive. This treatment commended itself to me as cheap, practicable, and effective for use while the lice are still confined to the terminals and while the vines are still upright, at which time, if at all, the lice must be combated if injury to the crop is to be prevented. I fear, however, that the profit in pea culture to the average grower is too small for him to ever engage in spraying, though the more successful growers could well afford it.

Could the fungous disease be grown in the laboratory and started in the fields early in the season it might prove of value, but so far our pathologist, Prof. F. D. Chester, has been unable to secure its growth upon any culture tried.

APHELINUS FUSCIPENNIS AN IMPORTANT PARASITE UPON THE SAN JOSE SCALE IN EASTERN UNITED STATES.

By W. G. JOHNSON, *College Park, Md.*

For the past eight years the writer has been paying particular attention to the parasites attacking scale insects. During this period many species have been bred, but not many specimens from any particular scale. The instance cited below is, perhaps, the most important from the economic standpoint yet discovered in these observations.

Since we assumed charge of the State work in Maryland we have collected the San Jose scale on various food plants, and inclosed infested twigs, about 4 inches in length, in glass cylinder tubes open at both ends. The ends were closed with cotton, and if any parasites existed upon the scales they were easily detected and mounted for study. Only upon rare occasions have we taken more than a half dozen specimens from a single tube. This experience has been repeated year after year until the fall of 1899.

Of the four species of true parasites known to feed upon the San Jose scale, three of them have been bred in Maryland. So far as I know *Anaphes gracilis* How., bred by Dr. L. O. Howard from scales from Charles County, Md., has not been reared from this scale from any other State. *Aspidiophagus citrinus* Craw. has been reared only in California from this pest. *Aphelinus mytilaspidis* Le B. and *Aphelinus fuscipennis* How. have been reared from scales taken at the following places in this State: Riverside, Annapolis Junction, Araby, and Mitchellville. Last fall, however, I discovered a new locality for *A. fuscipennis* near Easton, Talbot County, in an infested orchard along the Miles River. The orchard contained a miscellaneous variety of fruits, and all the trees were quite seriously infested with the San Jose scale. Instructions had been given the owner to cut them down as soon as possible and burn them. A quantity of small branches incrustated with scale were brought to the laboratory and inclosed in breeding tubes. Much to my surprise these tubes were swarming with parasites a few days later. From one tube 1,114 specimens of *Aphelinus fuscipennis* were taken; while a second tube gave 432, a third 1,478, and a fourth more than 1,000, but owing to an accident the count in the case last mentioned was not exact. The writer was greatly elated over this discovery, and immediately sent out the following statement to the State press:

I am advising my correspondents not to burn twigs and branches cut from trees infested with the San Jose scale. If the tree is so seriously infested it can not be saved; it should be dug up by the roots, trimmed, and the brush and wood piled in the orchard, where they should be left until about the 1st of June or longer. If the trees are to be sprayed with either, a 25 per cent solution of kerosene and water,

whale-oil soap (2 pounds in a gallon of water), or crude petroleum, the pruning should be done first and the cut branches gathered up and piled where the spray can not reach them.

This is done to preserve the little friends nature has supplied to help keep the scale in check. If the twigs and branches are burned or sprayed the parasites would be destroyed, as they feed upon the scale insects and are now wintering under the shell-like cover protecting them. These parasites are very small, being scarcely visible to the naked eye, yet they play an important part in the economy of nature. They are wasp-like in general appearance and quite active. It would be very difficult to estimate the actual number of parasites present upon a 5 or 6 year old peach or plum tree, but it is safe to say that they would run into the millions if the parasitism was at same rate as upon the twigs in the tubes.

If I had burned these twigs I would have destroyed all the parasites. On the other hand, if I had left them on the ground in the orchard the little friends would have escaped and concentrated their attacks upon other trees where the scale had been missed by the sprays. It is clear, then, that by using a little judgment in these matters we can assist nature in restoring the balance she desires. Do not sit down and fold your arms thinking nature is going to restore this equilibrium at once; you must do your part faithfully and well. Prune your orchard as soon as possible and save every twig that contains a scale; then spray with a 25 per cent solution of kerosene and water, using any first-class spray pump, or with whale-oil soap (2 pounds to a gallon of water), before the buds open.

There is no possibility of the scale spreading until some time after the 1st of June. The young begin to appear in the vicinity of Washington, D. C., June 10 to 15 [in 1900 young were seen by the writer crawling June 3 near Washington], and the insect continues to breed until very cold weather. We have seen young, just born, on trees as late as December 19. When a twig is cut off between, say, December 20 and May 15, there is no possible danger of the scale spreading from it. It is not possible to transfer one of these insects from one twig to another after it is "set" and formed a scale over its back, and all of them die as soon as the sap is dried out of a cut twig or branch. Badly infested trees of no commercial value should be cut down now as soon as possible, before the buds open, and the brush piled. Do not leave the stump standing, as it may prove a veritable breeding place during the summer. If you are so unfortunate as to have this scale, remember that eternal vigilance must be the order of the day, and you will find before you are through with it that it is no trifling matter.

The orchard in question was not destroyed by burning, as first suggested, but the trees were pruned and the cuttings saved. In May, 1900, the writer had a large quantity of the branches from this orchard carefully packed and sent to Mr. W. W. Cobey, Grayson, Charles County; to Capt. R. S. Emory, Chestertown, Kent County, and to Hon. Charles G. Biggs, Sharpsburg, Washington County. Instructions were sent to place the infested branches in grape baskets and hang them about the orchard where the scale was most abundant. In this manner we will establish *Aphelinus fuscipennis* in the various counties and under different conditions. We have every reason to believe that the experiment will prove successful.

In this case the study of parasitism has given us a valuable suggestion for the treatment of scale infested orchards, namely, never burn a twig or tree cut late in the fall, winter, or early spring. A positive

remedy one day may be wrong the next day, just as we are able to unravel nature's secrets and interpret them for our own good.

Since the above was read the writer has tested a lot of twigs from the Charles County orchard and has bred numerous specimens of *A. fuscipectus*, thus proving that a parasite is thoroughly established there.

THE BROWN-TAIL MOTH IN MASSACHUSETTS.

By A. H. KIRKLAND, *Malden, Mass.*

It is seldom possible to record with accuracy from year to year the spread of an introduced insect pest. The average working entomologist has at his disposal neither the time nor the funds necessary to follow the spreading swarms afield. It therefore follows that in such cases our records of insect dissemination have been built up by collecting and combining data in the possession of entomologists and laymen. This method is the only practicable one in the case of those insects whose spread is dependent upon the agency of commerce. Such cases do not possess the interest, at least from a biological standpoint, of those where natural means of distribution predominate.

The writer thinks the present a good time to record a few notes on the natural spread of the imported brown-tail moth in Massachusetts, particularly since the abandonment of work against this insect will prevent the accurate collection of further data.

With this insect in Massachusetts a unique condition has made it possible to follow its increasing distribution with more than ordinary accuracy. When the insect was first noticed in the State, in 1897, the work of combating it was placed in charge of the board of agriculture.

At that time the board had employed in the gypsy-moth work about 200 men, who from practical experience were fairly close observers of insect life. While it should not be understood that these men were experts, yet they were capable of recognizing the gypsy moth in all stages, and soon gained an equally accurate knowledge of the brown-tail moth, particularly after having experienced the intense nettling caused by the caterpillars. The duties of selected members of this working force included a search each fall to determine the extent of the spread of the brown-tail moth outside the area occupied the previous spring. With such employees the chance for erroneous determinations of the moth was small. The writer might add that he was able to verify the determinations in all doubtful cases.

In the paper read by Prof. C. H. Fernald before this body in 1898 a description was given of the high gale which, occurring in the flying season of 1897, disseminated the moth for many miles to the northward. This northerly spread is even more apparent at the present

time than was the case in 1898, and the greatest distribution has been in this direction. Taking the areas of the towns found to be infested from year to year, we have the following table:

Area infested, fall of—	Square miles.
1896.....	29
1897.....	158
1898.....	448
1899.....	928

While the moth was not discovered in Massachusetts until May, 1897, we were able to determine the area occupied in 1896, since this area of necessity was the same as that in which the hibernated caterpillars were found in the spring of 1897. For the same reason it is not possible to give the area occupied in 1900 until a full examination is made.

It is interesting to note that the fall inspection of 1899 showed the presence of the moth at Seabrook, N. H., some 40 miles from the point of its introduction. Since it has now passed beyond the borders of the State of Massachusetts, any legislation looking to the control of the insect would involve cooperation of Massachusetts and New Hampshire. Indeed, Maine should be added to the list, for a small colony of the pest was located at South Berwick, Me., by Prof. F. L. Harvey, as described in Bulletin No. 61 of the Maine Agricultural Experiment Station. Infestation at this point was doubtless due to the transportation of household goods from a badly infested estate in Somerville, Mass., at the height of the 1897 outbreak.

ENTOMOLOGICAL NOTES FROM COLORADO.

By CLARENCE P. GILLETTE, *Fort Collins, Colo.*

Colorado is of peculiar interest from an entomological standpoint. The Great American Desert lying along her eastern border shuts out a very large proportion of the fauna of the Middle and Eastern States. The mountains and barren wastes beyond her western border keep back most of the fauna of the Pacific States, and the backbone of the continent rising to more than 14,000 feet in places and extending north and south forms an almost complete barrier to the intermingling of eastern and western species within the State, except in case of those which follow in the wake of civilization and which are transported by man from place to place. The insect fauna, because of the barrenness of a large portion of Colorado, is small in individuals, while the number of species, because of the great variation in climatic conditions and in plant life, is very high.

These barriers to the migration of insects have been of great service to the people, for many of the pests that are common through the Eastern States have not yet reached us. In some instances this isola-

tion has seemed to be as positive a disadvantage, and that is where insects have been imported without nature's checks being brought with them. As a result they have increased to an unprecedented extent before the balance of nature was restored.

It is my object to give you a partial bird's-eye view of Colorado's condition from the standpoint of an economic entomologist. It will be impossible to mention more than a few of the important insect enemies.

The codling moth was unknown in several fruit growing regions of the State ten years ago, but now it is a serious drawback to the successful culture of the apple in every apple-growing section of any considerable size. In the warmer portions it is so bad as to almost dishearten the orchardist, and those who do not attend well to the application of the best remedies are barely able to market any perfect fruit except of the early varieties that catch the larvæ of the first brood only. Spraying with arsenites is quite generally practiced, and white arsenic is preferred by a considerable proportion of the growers because of its cheapness and ease of distribution. Bands of burlap are quite extensively used and with results that fully warrant their continuance as a means of capturing the larvæ.

A habit of the larva that I have not seen mentioned in any publication upon this insect was reported to me last year. Mr. A. V. Sharpe, of Fruita, Colo., at the time acting horticultural inspector for Mesa County, wrote me that a neighbor had taken larvæ of the codling moth in considerable numbers under fresh bands put upon the trees early in the spring. To test how extensive this spring migrating habit is I had bands put upon trees in several localities of the State the past spring, and a small number of the larvæ were taken, but hardly a sufficient number to make it advisable to adopt this method of combating the first brood.

Another matter of considerable interest in connection with the life habits of this insect was reported at a horticultural meeting at Grand Junction last winter, and well authenticated. A gentleman, whose name I can not recall, stated that a year or two previous he selected a number of barrels of very choice apples at the time of gathering in the fall and put them in a pit for the winter. He said he took particular pains to put no wormy apples in the pit, but when he opened the pit and took out the apples late in the winter he found to his astonishment that nearly every apple had a wormhole in it. The supposition was that a late brood of moths had deposited eggs upon the apples, and that they hatched and matured larvæ in the pit.

I should be glad to know if other members of the association have met with such an instance in their experiences with this insect.

Two leaf-rollers, *Cacæcia semiferana* and *C. argyrosbila*. These two species, of wide distribution over the country, have never been known

to do much harm outside of a small region situated near the foothills along the eastern slope of the Rockies in the northern half of Colorado. In this region, during the past ten years, they have been very serious pests. *C. semiferrana* confines its attacks in the region mentioned entirely to the box-elder, while *C. argyrosipila* is a very general feeder, being able to subsist upon the foliage of almost any deciduous tree or shrub. I have seen small orchards entirely defoliated by this species so that not a green leaf could be seen, and the box-elder species has been equally destructive to the foliage of that tree. At present these insects have nearly disappeared in Larimer County, but they are still very destructive in the vicinity of Denver and Boulder.

The case seems to be one where two closely-related insects reached, at about the same time, a region where their food-plants were abundant and their enemies scarce. As they have risen and fallen together in numbers, it seems probable that they are controlled in a state of nature by the same checks. We have bred not less than ten species of parasites from them.

The habit of the female of *C. semiferrana* in shingling her egg patches with the large flat scales from the underside of her abdomen is unique among insects so far as the writer is aware. Does anyone present know of a similar habit in another species?

The peach-twigg borer, *Anarsia lineatella*, has become a serious enemy in peach orchards on the western slope within the State. It has done much injury this year in pruning back the new growth on young trees, and promises to occasion a heavy loss of fruit a little later as the first brood has matured in large numbers. The most promising remedy so far seems to lie in the use of bands upon the trunks of the trees for capture of the larvæ, as in case of the codling moth.

The peach borer, *Sannina cecitiosa*, is present in the peach-growing sections, but for some reason does not do serious harm as yet.

The currant borer, *Sesia tipuliformis*, is as abundant in the northern portion of the State as I have ever known it anywhere.

The woolly plant louse, *Schizoneura lanigera*, probably ranks next to the codling moth in importance as a pest in apple orchards in the State, and is particularly abundant on the west slope. Tobacco dust is taking the lead as a remedy for the root form. The number of trees actually killed by this insect in the State have been quite small.

The pear and cherry tree slug, *Eriocampoides limacina*, is very destructive, particularly to pear foliage, wherever remedies are not promptly applied for its destruction. It is worst at present on the western slope.

The San Jose scale is as yet unknown within the State. The only member of the family Coccidae that has attracted any special attention is *Aspidiotus ancylos*, which I have seen rather abundant on several

occasions upon pear trees and which has in a few instances killed plum trees on the western slope.

The brown mite, *Bryobia pratensis*, occurs in myriads in orchards in the western portion of the State. As early as May 20 of this year the foliage of many pear, apple, and plum trees was showing very distinctly the bleaching effect of the attack of these mites. In the winter time there are portions of the trunk and limbs of the trees that are colored red with myriads of eggs that are to hatch the spring brood. The eggs are readily destroyed by strong applications of kerosene emulsion or by the lime, salt, and sulphur mixture, and the ordinary kerosene emulsion destroys the mites after they hatch.

Some farm and garden pests are as abundant in Colorado as anywhere, and among these are the imported cabbage butterfly, *Pieris rapae*, the cabbage louse, *Aphis brassicae*, the cabbage Plutella, *P. crucifera-rum*, the pea weevil, the squash bug, the onion thrips, and cutworms. In addition we have the bean beetle, very destructive to wax beans, and other enemies of less importance.

The beet army worm, *Laphygma flavimaculata*, made a very interesting record for itself last year in localities in the State where sugar beets were grown. I can not find that the insect has ever been reported as an injurious species before.

Specimens sent to Prof. J. B. Smith were named for me as above, and I afterwards found that there were specimens of the moth in the collection that had been taken at night at Denver and at Boulder.

My attention was first called to the insect as a beet enemy by Mr. C. E. Mitchell, with the Colorado Sugar Manufacturing Company, Grand Junction, Colo. Mr. Mitchell first wrote to another person, about the 20th of July (the letter never coming into my hands), stating that a worm had appeared in considerable numbers upon beets in portions of Grand Valley. On July 29 Mr. Mitchell wrote, saying: "The worms have disappeared almost entirely during the past week. They seem to have gone into the ground." On the 12th of August a telegram was received from Mr. Mitchell stating that the worms had again appeared, and asking me to go at once to investigate the matter. This I did. The caterpillars were scattered to some extent over the entire area planted to beets, but the chief injuries were upon newly broken ground between Grand Junction and Palisades. Not less than 200 acres of beets had their leaves badly stripped, and fully half this acreage was so badly eaten down that the crop was not worth harvesting. When the beet leaves were devoured, the caterpillars ate in just beneath the crown and then went down on the beet. In fields where the beet leaves were mostly eaten away, the caterpillars were crawling over the ground in all directions in search of food, and they seemed to be able to make use of almost any green thing for this purpose. Potatoes in some cases suffered badly, as did small fruit trees where

beets were planted in an orchard. August 16 the worms were pupating rapidly, about an inch below the surface of the ground, though there were many very young larvæ still on the beets. September 10 the moths were hatching in great numbers, and there were still scattering caterpillars on the beets. As mature ova could not be found in the female moths at this time, and no more larvæ appeared, it seems probable that the moths hibernate during winter. The sudden appearance of this insect in such numbers is almost unaccountable. For several years a few parties had been growing beets, in an experimental way, about Grand Junction, but no caterpillars had ever been seen before, so far as I was able to learn. Last year a sugar factory was erected, and a large acreage of beets was grown for the first time in that region. At Delta, a town 50 miles distant by rail, and at Montrose, 70 miles distant, where beets were also grown, the caterpillars appeared in considerable numbers, but were not so numerous as near Grand Junction. The larvæ were also sent me from Rockyford, where they were common on experimental beets, but not numerous enough to attract much attention.¹

The Arkansas Valley forms a sort of thoroughfare through which insect pests have come to Colorado from the East. It was here we first found the strawberry leaf-roller, *Phoropteris compta*, which is established as a serious pest on both slopes of the Rockies in limited localities. The cucumber beetle, *Diabrotica vittata*, is a recognized pest upon melon vines about Rockyford, but seems to have done no special harm in other localities, and the melon louse, now generally distributed over the State, seems to have reached us by the same route. Other insect enemies deserve mention, but I refrain from occupying more of your time.

NOTES ON INSECTS OF ECONOMIC IMPORTANCE FOR 1900.

By W. G. JOHNSON, *College Park, Md.*

The apple aphid, *Aphis mali* Fab., has been unusually abundant on apples this year. It was the first pest of any consequence that occasioned much correspondence. Twigs entirely incrustated with eggs of this species were frequently sent to the office during the fall and winter. The attack this spring was very general, especially in young orchards. I also found the same insect very common upon Kieffer pears in many places. The injury to apples has been very great.

The apple-tree tent caterpillar, *Obolodonta americana* Harr., appeared this spring on apples in all sections of the State. Many trees were entirely defoliated. In one instance I found a nest in a peach

¹ I have just received a letter from my assistant, Mr. E. D. Ball, bearing date of June 17, in which he states that the beet caterpillars have been hatching for a week at Rockyford, and that in some fields the beets are half eaten up now.

tree where the caterpillars had been feeding. This was the first and only colony of these insects observed by us injuring peaches.

The asparagus beetle, both *Crioceris asparagi* Linn. and *C. 12-punctata* Linn., were present this season in the asparagus-growing areas. The former species was very conspicuous, especially on young asparagus beds, in which much damage was done. The latter species was seen only three times during the early part of the season. Hand picking of the beetles was resorted to in most cases where young beds were attacked.

The bean leaf-beetle, *Cerotoma trifurcata* Forst., which we first observed in this State in 1896, was again very destructive to wax and Lima beans throughout the trucking areas. The early varieties were more severely injured than the later ones. Paris green in land plaster, at the rate of 1 pound in 80 to 100 pounds, dusted over the plants as the leaves expanded, proved an effective remedy. This was repeated two or three times at intervals of a week or ten days.

The black aphid of violets, *Rhopalosiphum violæ* Perg., was discovered in two greenhouses doing serious injury to violets.

The clover-leaf weevil, *Phytonomus punctatus* Fab., was very common over a large area of the State. Clover was injured to a considerable extent early in the season, and many growers were apprehensive about the safety of their crop. A fungous disease, *Empusa* (*Entomophthora*) *sphaerosperma*, appeared upon the larvæ, and by the middle of May it was difficult to find a living specimen. Their dead bodies were coiled about leaves, stems, grass blades, etc. The disease was widespread throughout the State, and of the same virulent character.

The Colorado potato beetle, *Doryphora 10-lineata* Say, has been a pest of a more serious character than one year ago. Paris green, applied both dry and in solution with Bordeaux mixture, has been effective.

The strawberry leaf-roller, *Phoropteris comptana* Froel., has been observed by us doing slight damage to strawberries in Anne Arundel and Caroline counties. In both cases hand picking of the leaves was resorted to, as spraying was not desirable.

The destructive green pea louse, *Nectarophora destructor* Johns., has maintained its notorious reputation as a ravenous pest to peas, and has this year extended its ravages into the Northwest (Wisconsin). The loss estimated along the Atlantic Coast States is placed at \$4,000,000 at this time (June 15); while the losses in the central West and the Northwest can not be estimated at this time. [Later: August 14 the writer received a letter from William Lorsen & Co., of Green Bay, Wis., in which they said they had planted 2,400 acres of peas, and had a fair crop upon all except the late plantings. About the 20th of July they noticed the louse upon a 500-acre field just ready to bloom, and in less than a week all the peas were dead and brown].

We have found sprays of all kinds ineffective. Our most satisfactory results were obtained when we brushed the lice from the plants and covered them with earth, using an Iron Age cultivator for that purpose. We have designated this the "brush and cultivator method." [For a more complete account of this pest see author's paper on page 55].

The fruit-tree bark-beetle, *Scolytus rugulosus* Ratz., has been a very conspicuous insect in orchard trees this season, especially those injured by the severe freeze of February, 1899.

The harlequin cabbage bug, *Murgantia histrionica* Hahn., has not been reported from any locality this season. We attribute its scarceness to the freeze of 1899.

The Hessian fly, *Cecidomyia destructor* Say, has been very destructive to all early sown wheat. Some late sowings were also injured. The fall of 1899 being very open, the fly seemed to continue its deposition of eggs much later than usual.

The imbricated snout-beetle, *Epicarnus imbricatus* Say, was reported to me as injuring the leaves of cantaloupe in Washington County May 23.

The imported cabbage worm, *Pieris rapae* Linn., has maintained its rapacious habits and done much injury to cabbage over a wide area of the State. Paris green, 1 pound in 100 pounds of land plaster, has been the most useful remedy.

The imported currant worm, *Pteronix ribesii* Scop., has been a very serious pest upon the currant and gooseberry in all parts of the State where these fruits are grown. Both Paris green and hellebore were used with satisfactory results. Hand picking was resorted to in many cases.

The Mediterranean flour moth, *Ephestia kuehniella* Zell., has been sent to me from New York, Pennsylvania, Ohio, Canada, and Australia the past season. We have found, by actual trial, that hydrocyanic-acid gas is the most perfect and effectual remedy yet tried for the flour moth and other mill pests. Large mills in Ohio, Pennsylvania, Canada, Oregon, and Texas have been successfully fumigated in accordance with the writer's directions. [For specific directions for using this gas in mills, etc., see author's articles in the "American Miller" (Chicago, Ill.), for September and November, 1899.]

The melon plant-louse, *Aphis gossypii* Glov., has again appeared in Maryland and promises to do serious damage in certain sections. [August: Was not so serious a pest as was anticipated. It was held in check by lady beetles and parasites]. Hand picking of leaves when first noticed and spraying others with 10 to 12 per cent kerosene emulsion were very effective.

The pale-striped flea-beetle, *Systema blanda* Mels., was again a serious pest to young tomato plants during the latter part of May. No satisfactory remedy has been found.

The pear-tree psylla, *Psylla pyricola* Forst., is doing considerable injury to some pear orchards in Kent County. Many trees were practically killed last season in the same orchards by this pest. No satisfactory remedy yet found.

The plum curculio, *Conotrachelus pennsylvanicus* Hbst., while present in all parts of the State in both peach and plum orchards, is not doing serious injury. [The so-called June drop in Maryland peach belts was comparatively light this season.]

The rose-chaffer, *Macrodactylus subspinosus* Fab., has been reported in one or two cases as injuring grapes on the Eastern Shore. It has not been abundant since the 1899 freeze.

The San Jose scale, *Aspidiotus perniciosus* Comst., has occupied a great deal of our attention. It is still the most serious orchard pest we have to contend with. Many new localities have been discovered by our inspections. We have found 20 to 25 per cent kerosene and water on peach just before the buds open very effective. We do not advise this strength for fall and winter on the peach. As a spring spray it has been very satisfactory in our mountain peach belt. After the fruit is gathered we will use a 10 per cent kerosene spray on infested trees. [The writer saw large blocks of peach in Georgia in July that had been sprayed with 10 per cent kerosene and water just after the fruit was removed. The scale was in most instances killed, with little or no injury to the foliage. In all cases some leaves were injured, but not enough to cause serious damage. On the other hand, however, where a 10 per cent crude petroleum and water solution was used the foliage was badly hurt and falling at the time of our visit, July 14]. As previously stated in former publications, the writer advises growers to use kerosene, even in diluted form, with every caution. It is a dangerous substance.

The stalk worm of tobacco, *Crambus caliginosellus* Clem., known also as the sooty corn-root webworm, has been conspicuous in young tobacco, especially upon grass or sod lands. No satisfactory remedy has been found as yet. Planters should avoid setting tobacco on sod land.

The striped blister beetle, *Epicauta vittata* Fab., as usual, has been quite a serious pest in tomato and potato fields. In one instance it destroyed a field of beets.

The striped cucumber beetle, *Diabrotica vittata* Fab., has been quite common in cantaloupe fields. No satisfactory remedy found.

The white-marked tussock moth, *Orgyia leucostigma* S. & A., as last year, has appeared in considerable numbers upon shade trees in Baltimore.

GENERAL NOTES.

In addition to the above, the potato-stalk weevil, *Trichobaris trinotata*, has been quite prevalent in the State in potatoes.

Pemphigus acerifolii Riley, reported by me as doing injury to maples at the Agricultural College in 1898 and 1899, has been quite

abundant this season. The pest disappears about the first week in July.

The bagworm, *Thyridopteryx ephemeraformis*, has been a serious pest in many places in the State to arbor vitae, apple, and locust. In two instances it injured apple trees in the nursery rows. Hand picking was very effectual.

The black peach aphid, *Aphis prunicola*, was quite abundant in some young peach orchards in May.

In three cases a June beetle, *Anomala binotata*, was reported as eating the foliage from pear and apple trees.

The red-legged flea beetle, *Crepidodera rufipes* Linn., was sent to me from three localities where it was found injuring the foliage of young peach trees. The trees in all cases were planted on newly cleared lands.

The American elm scale, *Chionaspis americana* Johns., was sent to me from Geneva, N. Y., and from Ames, Iowa, upon elm.

An undetermined species of *Lecaniodiaspis* was found by the writer in Baltimore County upon wild honeysuckle (Diervilla).

An undetermined species of aphid and cutworm was found doing serious injury to lettuce in a greenhouse in Montgomery County.

INSECTS OF THE YEAR IN OHIO.

By F. M. WEBSTER, Wooster, Ohio.

In point of destruction the Hessian fly outranks every other insect, when considered in connection with the wheat crop of 1900. It is doubtful if there will be over 20 per cent of an average crop in Ohio; the remaining 80 per cent may be largely charged up to the ravages of this pest. As an average crop in Ohio amounts to, approximately, 40,000,000 bushels, the loss may be computed at 32,000,000 bushels, which at the ruling market price would mean a loss of \$22,400,000, at least three-fourths of which, or \$16,800,000, can justly be charged up to the ravages of the Hessian fly. More extended studies of this outbreak and some of the meteorological phenomena connected therewith are given in another paper. The unprecedented abundance of the pest this year may be attributed largely to the almost total lack of parasites, the retardation of the fall brood over the northern half of the State, and the extremely favorable weather during the autumn of 1899, which enabled all but the very latest deposited eggs to hatch and the larvæ develop to the "flaxseeds" and thereby defy the adverse influences of winter. In many localities the later sown wheat escaped fall attack, and up to May 1, 1900, was uninjured, but the flies developing in the earlier sown fields seemed to have migrated *en masse* and settled down on those sown later, and the result is that in many cases the destruction is as complete in the one as in the other.

During the fall of 1899 the fall army worm, *Laphygma frugiperda*, committed serious depredations in southern Ohio, especially in Washington, Gallia, and Scioto counties. During March of the present year complaints came from the same section of the State, setting forth the continued ravages of this pest. As this seemed improbable, an assistant was sent to investigate the matter. That there was being considerable injury done in fields of young wheat there appeared to be no doubt, and an ample supply of the depredators were secured, but, instead of the supposed *L. frugiperda*, the pest proved to be no other than the spotted cutworm, *Noctua c-nigrum*, the larvæ having evidently lived over in the fields, probably above ground. I clearly recollect finding the larvæ of this same species feeding on young wheat in the fields during a January thaw at Lafayette, Ind., a number of years ago.

Early in May of the present year there came complaints of the attack of cutworms on the extensive onion farms in Hardin County. A personal investigation of these complaints resulted in my observing two separate invasions, the depredators being *Carnados tessellata* and *C. insignata*.

The worms ranged in length from nearly three-fourths inch downward to about one-fourth inch in length. In one case they were making their way from a tract of ground which had been planted to corn last year and had been somewhat neglected and grown up to weeds, though there were almost none of these growing there at the time of my visit. The other outbreak had originated near where a large lot of potatoes had been pitted last fall and remained there over winter. Here, too, there was no vegetation on which the worms could have subsisted up to this time. The cutworms in each case would follow the rows of young onions, taking nearly every one as they went, in one case invading the field at the ends of the rows and in the other along one side. Larvæ brought to the insectary fed on red clover, the adult moths appearing largely on June 16, but others continued to put in their appearance for several days.

A mixture of wheat bran and arsenic, mixed into a dough with sweetened water and this placed under boards laid down in the midst of where the worms were at work, proved very effective and soon reduced their numbers.

It is not often that the wheat wireworm is known to attack other grains. An instance, however, was brought to notice this spring where a wheat field that had been hopelessly ruined from the attacks of Hessian fly last fall had been plowed up this spring and planted with corn. May 28 the owner of the field, Mr. E. R. Emerich, of Greenville, Ohio, wrote me saying that the corn had been badly injured by these worms, specimens of which accompanied his letter of complaint.

One of the most serious outbreaks of the corn billbug, *Sphenophorus sculpitilis*, occurred in a field of timothy of three years' standing, containing 35 acres, which was broken during March of the present year, and on the 13th of May was planted with corn. June 6 the owner came to me with specimens of this beetle, claiming that the corn over the entire field had either been killed outright or hopelessly ruined from attacks of this pest. A visit to the field a few days later revealed a state of affairs that had not been overdrawn by its owner, with the exception of a few acres along one side, over which it was represented the timothy had been killed out by some unknown cause and redtop had taken its place. Here the injury had been very slight, but through the remainder of the field the damage was almost total. The owner had noticed that much timothy the year before whitened and died, but had not learned the cause. On examination I was able to find a considerable abundance of the timothy roots that had been hollowed out, clearly by the larvæ of this insect. While slight injuries by this pest are not uncommon in Ohio, Indiana, and Illinois, I never before saw so large a field of corn so thoroughly and effectually destroyed by these insects. In this case the only thing it seemed possible to advise was the replanting of the field between the old rows, leaving the remnant of the first planting to engage the insects during the remainder of their life, and thus, as it was hoped, to keep them away from the second planting.

Onion thrips, *Thrips tabaci*, were excessively abundant in some localities last year. In order to learn something about the winter habit of this insect frequent visits were made to onion fields where it occurred in greatest abundance during the fall of 1899. These visits were made during the entire winter whenever the weather was suitable, the result being that the insect was found in matted blue grass and in the piles of refuse onions that had been left in the field, but more especially in the matted grass along ditches. It was found to winter over in all stages except that of the egg. A study of the various onion fields in northern Ohio has shown that where the surroundings have been kept free of matted grass and largely cultivated there has been the least injury from these insects. The fact that it winters over in several stages of development fully explains the difficulty of tracing out generations in the field. On one extensive onion plantation that has heretofore been intersected by open ditches, the banks of which were grown up with blue grass, the experiment of destroying this grass is being carried out. As the field is situated on muck land it was, of course, impossible to burn these grassy banks over in the ordinary way, and therefore they were first sprayed with kerosene while the ground was still frozen and then fired. Either by this means or by plowing all of the grass along the banks of the ditches has been destroyed, and will be prevented from growing the present

season. From all of the information we have at present obtained it would seem as though outbreaks of this pest may be largely prevented in this way, and it has been demonstrated by actual experimentation that the insect can be destroyed by spraying the plants along the edges of the fields when they first begin to show the effects of attack with a mixture of 1 pound of whale-oil soap dissolved in 8 gallons of water.

Although this thrips in Russia is a tobacco insect, it invariably declined to feed upon tobacco with us, and held strictly to the onion. Lest I might be mistaken in regard to the species, specimens were submitted to Mr. Pergande, who compared them with Russian specimens, and informed me that there was no doubt but that we were dealing with the true *Thrips tabaci*.

In early April, 1897, the writer found adults of *Myochrous denticollis* attacking young corn in the fields in Tensas Parish, La. No serious injury, however, seemed to follow, and this, so far as known to me, is the only published record of the food habits of the insect. On June 2 Mr. Alva Agee, of Cheshire, Gallia County, reported that the insect had attacked the young corn in his neighborhood, apparently working serious injury. Specimens of the beetles were sent with the complaint. On June 4 my assistant, Mr. Newell, was sent to the locality to investigate the outbreak, and found that the territory infested comprised all the cornfields contained in an area of 3 miles square. In all cases the infested cornfields were upon land which had been the year previous either in pasture or lying out wild. A very few of the beetles were found upon blue grass. In the insectary, however, they seemed to prefer corn first, next timothy, and lastly the blue grass. In this case the beetles were not observed to feed upon the stems of the corn plant below the surface of the ground, but upon the leaves and leaf sheaths. The feeding was done during the morning and evening, or upon cloudy days. When there were drifting clouds the beetles would come out and feed while the sun was under a cloud, but go back into their hiding places in the ground when the sun came out bright and warm. During the day they were observed to hide in the crevices of the soil and in the loose dirt near the corn plants, from 2 to 15 being found in close proximity to the different hills. The beetles are densely punctate on the back, and these cavities retain more or less of the soil, which gives the beetles the same general color as the ground. They seem to have no inclination whatever to fly, but run quite rapidly. One female that was dissected contained 5 yellow, cylindrical eggs, estimated to be about 1 mm. in length.

It would therefore appear that the insect is one that feeds upon, and probably its larvæ also develops upon grass. In the latter stage it appears to be of subterranean habits. At present no remedial or preventive measures have been tried.

The destructive pea louse was found in various parts of the State during October, 1899. On the grounds of the experiment station at Wooster it was destroyed in myriads by the fungus *Empusa aphidis*, as determined for me by Dr. Thaxter. Owing to the destruction that this insect has caused along the Atlantic coast it was watched for with a great deal of interest at the beginning of the present season. A small field was sown with oats and the Canada field pea during April, but no specimens of the insect could be found upon the peas until May 30, when a single winged female was found with a number of young upon the vines. At the same time, what appeared to be the same insect was found in greater abundance upon the red clover, growing also on the station grounds. Specimens both from the pea and the red clover were determined for me by Mr. Pergande, through Dr. Howard, as *Nectarophora destructor*. This coincides with a suspicion that I have had since the pest first came to notice in Maryland and through the Atlantic Coast states, namely, that the same thing occurred here in Ohio upon the red clover.

Last fall, however, we tried to colonize individuals taken from the Canada field pea and placed upon red clover, but failed in the undertaking. Although this was not conclusive evidence, nevertheless it seemed to some extent to discredit the idea that the aphid on the clover and the one on the pea are the same; besides, I had fresh in my mind the experience with the tobacco thrip, as previously stated.

The first report of serious injuries from this pest came from a firm of growers and packers of vegetables, Messrs. Sears & Nichols, of Chillicothe, who, under date of June 12, report attacks from the insect and severe damage in a few spots in their fields of growing peas. On the station grounds the louse is being destroyed in considerable numbers by a species of Praon.

On the 17th of June, 1898, there came a complaint from Flushing, Belmont County, of serious injury to the ripening strawberries. Mr. Mally, my assistant at that time, was sent to investigate the matter. Specimens of the bug *Myndocha sciripus*, had been sent by the owner of the premises as the probable depredator. Mr. Mally was not able to solve the problem, but saw at once that the injury must have been due to the attacks of an insect with a biting mouth, as it did not appear to depredate especially upon the pulp of the berry, but upon the seeds, the hulls of which were invariably thickly strewn upon the ground or fallen leaves underneath the injured berries. There was also a similar complaint from Greene County, and this was also accompanied by specimens of the same insect. Nothing was heard of this trouble last year, but June 11th of the present year I received a telegram from the owner of the premises at Flushing, to the effect that the insects were again at work upon his strawberries. A personal visit to the locality very soon developed the fact that the cause of the damage, which was

severe, as it had also been in 1898, was due to the attacks of a large black beetle, *Harpalus caliginosus*. Years ago I recorded the fact of this insect attacking the seeds of ragweed, but it has usually been considered predaceous, and therefore beneficial. The beetle seems not to care at all for the berry, either green or ripe, but in extracting the seeds it leaves the ripe berry a pulpy mass that is absolutely worthless, while the younger berries are so gnawed upon the surface as to prevent their maturing. Wherever the clusters of injured berries were found in the field one or more of these beetles was to be found in the near vicinity, generally hiding away under a clod, a small stone, or in holes in the ground. An examination of the stomach of freshly caught beetles showed a vast amount of the softer portions of strawberry seeds reduced to small bits. In no case did the hull of the seed appear to have been eaten. The beetles are large and conspicuous, easily trapped and killed when it is once known that they are the authors of the mischief, but in every case where this injury has been reported to me, specimens of the *Myodocha* have accompanied the complaint. I have already received other reports of this injury from the same vicinity. One of the persons who has suffered from the ravages of this insect states that they worked very badly on his premises in 1898, but not very severely in 1899, but this year again they are seriously destructive. Burning the patches over does not seem to be effective. From the fact that the Hemipter has always accompanied the first complaints of this trouble, I am wondering if the published reports of its injury in other States have not really been due to the work of the *Harpalus*.

On August 28, 1899, while Mr. Mally was inspecting a small nursery, he found what he took to be larvæ of the round-headed apple-tree borer, working in the bases of young linden trees. These were transferred to a breeding cage in the insectary. June 15 of the present year it became necessary to move this cage and in the badly eaten and partially decayed wood about 4 inches below the surface of the ground, active larvæ were found. On April 3 of the present year there emerged from one of these stumps an adult *Saperda vestita*. April 4 the material still remaining in the breeding cage was examined, and one larva and one pupa were found still in the wood. The larva had worked in the wood and tap root entirely below the surface of the ground, the upper limit of the work of the larva being from 2 to 4 inches below the point that marked the surface of the ground where the trees had been growing. When ready to pupate the larva seems to bore upward in the wood to what would be about on a level with the surface of the ground, and pupates in a cell cut diagonally across the grain of the wood at an angle of about 45 degrees to the upward channel. This insect has always been known as attacking the linden, but I believe this is the first record of its being found attacking trees below the surface of the ground.

Monarthrum fasciatum has been sent me the present year in the adult stage boring in both bark and wood of the maple.

Eriococcus azaleae occurs quite abundantly this year on *Rhododendron catawbiense*. The shrub had been growing on the station grounds since 1897, therefore, it had stood one more severe winter, that of 1898-99. The shrub was isolated and the insect not at all likely to have been introduced since it was planted.

Colaspis brunnea has been excessively abundant this year and has been reported as destroying young buckwheat and beans. I have also noted it attacking four-o'clocks.

Pseudococcus aceris has attacked the hard maples, *Acer saccharina* to quite a serious extent in New Philadelphia. No other variety of maple was injured.

NOTES FROM CALIFORNIA.

By C. W. WOODWORTH, Berkeley, Cal.

This being, I believe, the first time a member from California has attended a meeting of this Association it will be quite appropriate to give a general account of the entomological situation in the State rather than the usual notes on the insects of the year.

California is not comparable with any other one State, for there are included within her boundaries nearly as many climatic conditions as are found in all the remainder of the United States.

The great agricultural region of the State is a large valley surrounded on all sides by mountains. The Sacramento River flowing from the north and the San Joaquin from the south meet and empty their waters in the Bay of San Francisco. This valley is the region of our greatest grain fields, orchards, and vineyards. Cut off as it is by mountains from adjoining regions, not only does it form a unit as regards its climate but the native fauna and flora are quite distinct. Fortunately most of the native insects are developed for vegetation of a more or less desert type and few have made themselves felt by their injury to cultivated plants. A few cutworms, some native beetles of several kinds, but with habits of the eastern *Macrodaetylus*, and two or three species of migratory grasshoppers from the surrounding highlands are the most abundant, though small local injury is occasionally done by many species.

There is some variation in the great valley. It is well watered to the north and along the eastern side, becoming quite a desert in the south and west, except as reclaimed by irrigation. The largest irrigation systems in the State water the southern portion of this valley. The trough of the valley is more or less frosty, but along the foothills and in the south, even partly on the plains, there runs a thermal belt on which oranges are grown to perfection. Still higher up on the hills these are replaced by the hardier fruits of the temperate zone.

Southern California is separated by a range of mountains into a comparatively narrow fertile coast region and a dry interior valley, consisting of a high plateau, northward the Mohave Desert, and southward the low Colorado Desert, dipping in one place below the level of the sea. There is also an insignificant fertile strip along the Colorado River which is quite tropical. The coast region is the California mostly known to Eastern people. Here is where the great orange and lemon orchards are found. The summers are not as hot as are those of the great valley to the north, because of the influence of the ocean. Thus the shipping of early fruits is from the north to the south; even oranges, which ripen in winter, are being shipped from northern California fully a month earlier than from southern California. The insect fauna of this region is enriched by many Mexican forms, and differs strikingly from that of the great valley. Economically, most of their problems are as different as are their practices.

The central portion of California, along the coast, consists of numerous valleys, each famous for the perfection of some product. The apple, prune, and wine grapes, for instance, are here at their best. South from San Francisco the insect fauna is very distinctive, with numerous peculiar local forms, some of considerable economic importance, while north of the bay the fauna shades off on the one hand with that of the great valley, and on the other with the north coast region.

The northern part of the State is mountainous or high lava beds. To the eastward and along the coast is a rather narrow fertile region having very heavy rainfall. Here dairy interests predominate. The fauna is practically the same as that of Oregon.

To bring out more strikingly the economic significance of these divisions, let us now review some of the more injurious insects.

SCALE INSECTS.

Scale insects have attracted more attention in California than has any other group. The most injurious species at the present time is the black scale (*Lecanium oleae*). In the south it is most troublesome on oranges and lemons, although it is also bad on olives and deciduous fruits. In the north it is injurious to olives and deciduous fruits in the coast valleys only, scarcely appearing in the great valley, which seems to be too dry for it. It is chiefly against this insect that fumigation with hydrocyanic-acid gas is practiced, but only as it occurs on citrus trees. On deciduous trees resin-soap wash in winter is chiefly depended upon, but it is unsatisfactory on citrus trees. On these trees fumigation has come to be considered the only remedy. Some time ago a good deal of stir was made about the work of an Australian ladybird (*Rhizobius ventralis*), and possibly all present may not know that it has in no way duplicated the results produced by the *Tedalia cardinalis* on the cottony cushion scale (*Icerya purchasi*). The other

orange scales have given trouble only in the south, and are also controlled by fumigation.

The San Jose scale (*Aspidiotus perniciosus*) is still with us in California, but is so well in control that it is scarcely ever mentioned when discussing injurious insects in conventions or meetings of farmers. It occurs all over the State, but is chiefly to be found in the great valley. The treatment almost uniformly adopted is winter spraying with lime, salt, and sulphur mixture. The idea that it is troublesome only in the north is not correct.¹ It is less injurious near the coast (San Jose and southern California) than in the interior (Marysville), but it is rather more injurious in the San Joaquin than in the Sacramento valleys. The use of the lime, salt, and sulphur mixture is so beneficial to the tree that it is often used when the orchard is free from scale. Our very dry, hot summer weather has a tendency to unduly thicken the bark much as the attacks of the scale insects do, and nothing we know of in the way of a bark corrodent is as safe and effective, leaving the bark in so perfect a condition as this. The wash does not kill the insects, at least not very completely at once, but perhaps as much by the corrosion of the bark as anything else effectually rids the tree of the insects attached to it.

CODLING MOTHS.

The codling moth, next to scale insects, has received attention. It occurs over most of the State and presents a most diverse set of life histories according to the location. In some places it is still unknown (isolated orchards along the Sierra foothills); in others, while present, it is so unimportant as to require no treatment (several localities exposed to the ocean winds).

Again, in a good many localities the insects come late in the spring and perhaps have but a single brood, and one spraying any time before the fruit is half grown seems to be satisfactorily effective. A still larger number of localities require the spraying to be once carefully done and properly timed for early fruit, and two or three additional sprayings late in the season if late fruit is to be saved. Finally, some situations are so bad that a continuous warfare must be kept up from the time the blossoms open till the fruit is picked. Indeed, some of our fruit, especially fancy apples for export, is picked over two or three times after storing in the packing house to allow the development of worms that could not be discovered at picking time.

PEACH WORMS.

The peach worm (*Anarsia lineatella*), which winters as a borer in the bark, becomes a bud worm in the spring, and in the second generation bores into the ripe fruit, is one of our most troublesome peach

¹J. B. Smith, Rep. State Ent. N. J.

insects. It shows some of the same peculiarities as to abundance and ability to do injury, but in some regions, as at Berkeley, is practically unknown.

The Eastern peach borer, as well as the curculio, has not found as yet a home in California. The former has without doubt been many times introduced into the State on nursery stock. Why they have not become acclimated is very difficult to understand. We have a native peach borer, *Sannina pacifica*, belonging to the same genus and with the same habits, which in its distribution is quite as mysterious. This insect makes its home in the neighborhood of San Jose and has undoubtedly, even to a larger extent than the Eastern species, been sent in nursery stock over the State, but it is still quite unknown except in that one region, where it is quite as much a pest as the *S. exitiosa* has ever been in the East.

GRAPE INSECTS.

Since California is the only region where the European grape is grown, it is only with us that the phylloxera is an important insect. Vineyards have been destroyed over whole valleys, as occurred in Europe, but the insect proves to be very much slower in spreading than in Europe, which corresponds with the difference in life history in California. The winged form, being produced only after long intervals, apparently requires conditions which in most years do not occur.

Next to the phylloxera the vine hopper (*Typhlocyba comex*) (ours is a variety somewhat intermediate between *coloradensis* and the typical *comex*) is injurious only in the great valley and in the coast region north and west of San Francisco Bay. In the early spring it often comes in such immense numbers as to cause the distortion of the young leaves by the partial atrophy of the vine, causing them to have something the appearance of curled leaf lettuce. After the first leaves have become mature they insert their slender curved eggs just under the cuticle of the leaves beneath, and young are produced from then on continuously till the leaves fall. By autumn, if nothing checks them, they are more numerous than I have ever seen them in the East. They are abundant enough every spring to easily destroy all the foliage before the season is over, but through disease or other calamity, exactly what, I have never been able to satisfy myself, their numbers are usually reduced so that it is possible to raise grapes.

The remedy usually suggested for vine hoppers is winter "cleaning up," but the usual practice in most parts of our vineyard districts is to clean up more thoroughly than would be thought possible in the East. It is certain that the clean vineyards are most injured by the hoppers in the spring, although by midsummer little difference can be noticed.

Another vine hopper belonging to a different subfamily, and I

believe the only member of its genus ever becoming seriously injurious, is *Tettigonia circillata*. It is as injurious and in every way entirely replaces the small vine hopper in the Santa Clara Valley, and while occurring all over the coast region southward is nowhere troublesome. It differs from the *Typhlocyba* in breeding in the winter and on other plants as well as on grapes in the summer time.

It is not necessary to bring up further examples to show how clearly the distribution and habits of insects depend upon their environment, and the necessity in a region of such diversity as California of making local investigations before having any sound basis for economic practice.

NOTES FROM CANADA.

By JAMES FLETCHER, *Ottawa, Canada.*

The economic entomologist has had full opportunity this spring of studying injurious insects in all parts of Canada. Owing to the attention which has been directed to the subject by legislation connected with the San Jose scale and other injurious insects, many people have noticed insect injuries which otherwise would have been overlooked.

An important concession was made by the federal government last spring in allowing nursery stock to be imported into Canada subject to fumigation in houses specially prepared and in charge of a government officer.

Tent caterpillars of the two common species, which during the last three years have been extremely abundant in eastern Canada, were noticeably less destructive. Although many hatched in some places, they disappeared suddenly and few produced the perfect insects. The cause of this sudden disappearance was not detected in most cases.

Leaf rollers on apple trees were very destructive toward the end of May in orchards along the northern shore of Lake Ontario, the two commonest species being *Lophoderus quadripunctatus* and *Cacaecia rosaceana*. Both of these insects are common at Ottawa and have done a considerable amount of harm for several years, but they have been particularly abundant this summer. In 1891 and 1892 apple trees on the experimental farm were almost denuded in the spring. The larvæ of *Lophoderus* eat the green portions of the leaves, reducing them to masses of dirty white down, the pubescence from beneath the leaves, and fragments of leaves. Another injury to apple trees of some interest which has been complained of this year rather more than usual is an attack upon the flowers by the click beetle *Corymbites tarsalis*. The beetles eat holes into the petals and destroy the essential organs as well. *Micropteryx pomivorella*, usually a rare insect, has been found in considerable numbers in the Niagara district, and specimens have also been sent from Nova Scotia. The curious little cocoons in some instances have been sent in as scale insects. They

bear a slight resemblance to some species of *Lecanium*. The oyster-shell bark louse, in most parts of Canada a serious enemy of the fruit grower, has been much reduced in numbers by the parasite *Aphelinus mytilospidis*, which has been at work all through the Niagara district. Experiments have been tried with several of the usually recommended remedies for the oyster-shell bark louse, and the results of some experiments with a simple lime whitewash, which have been carried on by Mr. W. T. Macoun, horticulturist at the Central Experimental Farm, are worth mentioning. When spraying trees with whitewash to retard the opening of the flower buds, Mr. Macoun noticed that the bark lice were killed and scaled off in large numbers from the trees as the whitewash fell, and from present appearances the results of spraying fruit trees infested with the oyster-shell bark louse are such as to indicate that this will prove a valuable, simple, and inexpensive remedy.

ROOTS AND VEGETABLES.

The most troublesome insects this season under this head have been the root maggots of the onion and cabbage. Many remedies have been tried, but nothing actually new has been learned. The Gough tarred-paper disks have been very successfully used, and for cabbages and cauliflowers with more satisfaction than anything else. These have been fully described by Mr. Slingerland. Among the insect enemies of the pea, the pea weevil (*Bruchus pisorum*) is still abundant in some parts of Canada—a fact, I think, due to greater negligence on the part of seedsmen in treating seed than was formerly the case. The destructive pea aphid has not yet made its reappearance in Canada this season. The white cabbage butterfly (*Pieris rapæ*), every year the cause of much loss to cabbage growers, has now reached Vancouver Island, and thus extends from the Atlantic to the Pacific. The red turnip beetle (*Entomoscelis adonidis*) has appeared rather earlier than usual in the Northwest, where it attacks all cruciferous plants. It is particularly attracted by the wild crucifers, *Sisymbrium incisum* and *Erysimum inconspicuum*. Although no serious loss has as yet been reported from this insect, with the gradual settling up of the prairie provinces it is to be feared that this will become a serious pest of cabbages, turnips, and radishes.

CEREALS.

One of the serious outbreaks of the present season is by locusts (*M. spretus* and *atlantis*) in Manitoba, which hatched out remarkably early this year, namely, by May 20, and owing to the exceptional drought have already done much harm to crops. Cutworms have also been abundant in wheat fields. A new attack of much interest in the wheat fields of Manitoba last year was by the Hessian fly, which reduced the crop from 5 to 25 per cent in different places. Another of the old

time enemies of the wheat plant also showed up again last year in two or three parts in Canada, namely, the wheat midge (*Diplosis tritici*).

Of mill insects the Mediterranean flour moth continues to be troublesome, and an interesting occurrence was found a few miles from Ottawa, where the insect in a badly infested mill was abundantly parasitized by a small Linneria, probably *L. fugitiva*. The ordinary meal moth (*Pyralis farinalis*) was the author of considerable loss in stored grain at one locality in Manitoba.

FODDER PLANTS.

The clover weevil (*Phytonomus punctatus*) has as usual been found in one or two places along Lake Ontario this spring, but, as has always been the case with us in Canada, was quickly wiped out by the fungus *Entomophthora phytonomi*. A far more general and destructive insect to clover with us is the lesser clover weevil (*P. nigrirostris*). Three or four occurrences have been reported in the Province of Ontario of the clover-root borer (*Hyglastinus obscurus*), but the loss has not been great.

TREES AND SHRUBS.

Probably the items of the greatest interest under this heading were the abundant occurrence in Manitoba and the Northwest of some insect enemies of the ash-leaved maple (*Negundo aceroides*), the Negundo gall gnat. The fleshy galls of a cecidomyiid-like larva were found in enormous numbers on the young leaves in June. Wherever this tree had been planted for shade or ornament throughout Manitoba and as far west as Indian Head, the trees were much disfigured. There appears to be only one brood in the year. Occurring on the same trees were the larvæ of the cankerworm (*Alsophila pomataria*), which in many places stripped the trees of leaves. This is a constantly recurring enemy of the ash-leaved maple in Manitoba. Another serious enemy of this much burdened tree is the aphid (*Chaitophorus negundinis*), which renders the trees filthy by reason of its copious honey dew and the black fungus which grows upon it, Fumago. The larva of a small moth also causes swelling in the twigs while green and subsequently most of these twigs are permanently injured. The moth was identified by Dr. Riley as *Proteoteras æscularia*.

There are of course many other insects which might be mentioned, but these are the most interesting I can think of at the present moment.

All the papers having been presented, the following discussions took place:

Mr. Woodworth called attention to a method of combating the codling moth frequently used in California. He stated that the California growers at the time of cultivating their trees in the fall frequently

banded the trees with cloth or straw, and that these bands serve to collect the codling-moth larvæ, which were then destroyed.

Mr. Gillette had observed the larvæ of this insect migrating on the tree trunks in the spring, contrary to what was supposed to be their usual habit. He had observed the larvæ leaving their winter cocoons and moving about on the tree trunks at this time. In his opinion banding the trees in the spring was a valuable means for fighting the insect.

Mr. Johnson, in explanation of the common name of *Nectarophora destructor*, stated that this name had been decided upon jointly by Messrs. Pergande, Chittenden, and himself; that while the name was perhaps open to criticism, it was probably as appropriate as any. He also called attention to Mr. Lounsbury's statement that the red scale occurred on other than citrus trees in South Africa, which fact is of great importance and worthy of emphasis.

Mr. Lounsbury said that the red scale was a very common pest on the pear in South Africa, that it had an extremely wide range of food plants, and that its effect on growing wood was similar to that of the San Jose scale.

Mr. Felt, discussing the matter of common names of insects, expressed the opinion that a strict enforcement of the law of priority is hardly practical in such cases. It is difficult to change a well-established common name, however inappropriate it may be. He cited the failure of an attempt to change the common name of *Clisiocampa diss-tria* from "forest tent caterpillar" to "forest tentless caterpillar."

Mr. Fletcher felt that entomologists were open to grave criticism in not establishing appropriate common names for injurious insects. He suggested the appointment of a committee to secure uniformity in common names of insects.

Mr. Woodworth, referring to an experience in this line in California, stated that the board of horticulture of that State had formally voted to call *Aspidiotus perniciosus* the "pernicious scale," but in spite of their efforts to secure a standing for this name the pest was still generally known as the "San Jose scale."

Mr. Hopkins discussed at length the confusion arising from variation in common names. It was, in his opinion, highly desirable to have a uniform common name for each injurious species, similar to those adopted by the American Ornithologists Union. He also moved the appointment by the chair of a committee on common names.

Mr. Johnson, referring to the motion just made by Mr. Hopkins, called attention to the lack of system in selecting common names of scale insects. For instance, *Aspidiotus ancylus* Putnam was known as the "Putnam scale," *Aspidiotus forbesi* Johnson was known as the "Forbes scale," etc.

Mr. Kirkland thought the members were wasting valuable time on this matter of common names. Entomologists, to be most useful to their *clientèle*, must use the most common name of the injurious species under discussion, and it would be impractical to confine entomologists in different parts of the country to a single common name for an injurious species.

Mr. Lounsbury said it would be impractical to write of the "woolly aphis" of the apple in South Africa, since there *Schizonura lanigera* was everywhere known as the "American blight," yet the name "American blight" would hardly be serviceable to the reading public in this country. In the same way the "corn worm" of the North (*Heliothis armiger*) was the "cotton-boll worm" of the South.

Mr. Fletcher considered that some arrangement to secure uniformity in common names of insects would not be impracticable, since it had been made to work well in the case of birds.

Mr. Johnson thought the scope of the committee should be confined to the establishing of common names for such new species as should hereafter prove injurious.

After the acceptance of the amendment offered by Mr. Johnson, it was resolved that a committee, to consist of Mr. Gillette, the first vice-president, and the secretary of the Association, be appointed to pass upon the common names of such injurious insects as may be discovered in the future.

Mr. Fletcher expressed a desire that the committee also be given power to remove ungainly and inappropriate names, and offered an amendment to this effect, which was accepted and adopted.

A letter from Mr. Cooper Curtice, of Raleigh, N. C., relative to the need of securing a uniform list of injurious insects for use in quarantine work was read, and upon motion of Mr. Johnson laid upon the table.

The regular routine was suspended to admit the proposal of two new members:

C. B. Simpson, of Ithaca, N. Y., proposed by Mr. Sanderson.

Henry Skinner, of Philadelphia, Pa., proposed by Mr. Hopkins.

The committee on nominations proposed the following officers for the ensuing year:

President, C. P. Gillette, of Fort Collins, Colo.

First vice-president, A. D. Hopkins, Morgantown, W. Va.

Second vice-president, E. P. Felt, Albany, N. Y.

Secretary-treasurer, A. L. Quaintance, Experiment, Ga.

The report of the committee was accepted and the officers above mentioned elected.

A vote of thanks was tendered the retiring secretary for his services during the past two years.

The report of the committee on resolutions, given below, was accepted and adopted, viz:

Resolved, That we regret the absence of the president of the Association, and that we extend to the acting president our thanks for his able address, and commend his suggestions to the consideration of all members of the Association.

Resolved, That we request the honorable Secretary of Agriculture to publish the proceedings of this meeting, and that we express to him our hearty appreciation of such action in previous years.

Resolved, That we express our thanks to Columbia University and its officers and the local committee for courtesies extended the Association.

E. P. FELT,
W. G. JOHNSON,
A. F. BURGESS,
Committee.

It was voted to hold the next annual meeting of the Association at the same place and on the two week days preceding the next annual meeting of the American Association for the Advancement of Science, which will be held in Denver, Colo., August 24-31, 1901.

Adjourned.

A. H. KIRKLAND, *Secretary.*

LIST OF THE MEMBERS OF THE ASSOCIATION OF ECONOMIC ENTOMOLOGISTS.

ACTIVE MEMBERS.

Adams, M. F., City Bank Building, Buffalo, N. Y.
Aldrich, J. M., Agricultural Experiment Station, Moscow, Idaho.
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Ashmead, William H., U. S. National Museum, Washington, D. C.
Baker, C. F., Normal and High School, St. Louis, Mo.
Ball, E. D., Agricultural Experiment Station, Fort Collins, Colo.
Banks, C. S., Capitol Building, Albany, N. Y.
Banks, Nathan, U. S. Department of Agriculture, Washington, D. C.
Barrows, W. B., Agricultural College, Mich.
Beckwith, M. H., Elmira, N. Y.
Benton, Frank, U. S. Department of Agriculture, Washington, D. C.
Bethune, C. J. S., 500 Dufferin avenue, London, Ontario.
Bogue, E. E., Orwell, Ohio.
Britton, W. E., New Haven, Conn.
Bruner, Lawrence, Agricultural Experiment Station, Lincoln, Nebr.
Bullard, W. S., 301 Lafayette street, Bridgeport, Conn.
Burgess, Albert F., Agricultural Experiment Station, Wooster, Ohio.
Busck, August, U. S. Department of Agriculture, Washington, D. C.
Campbell, J. P., Athens, Ga.
Chambliss, C. E., 2435 Virginia avenue, Knoxville, Tenn.
Chittenden, F. H., U. S. Department of Agriculture, Washington, D. C.
Clifton, Richard S., U. S. Department of Agriculture, Washington, D. C.
Cockerell, T. D. A., Mesilla Park, N. Mex.
Collins, Lewis, 177 Remsen street, Brooklyn, N. Y.
Comstock, J. H., Cornell University, Ithaca, N. Y.
Cook, A. J., Pomona College, Claremont, Cal.
Cooley, R. A., Agricultural Experiment Station, Bozeman, Mont.
Coquillett, D. W., U. S. Department of Agriculture, Washington, D. C.
Cordley, A. B., Agricultural Experiment Station, Corvallis, Oreg.
Doran, E. W., Normal School, Clinton, Mo.
Ehrhorn, E. M., Mountainview, Cal.
Felt, Ephraim P., Capitol Building, Albany, N. Y.
Fernald, C. H., Agricultural College, Amherst, Mass.
Fernald, H. T., Agricultural College, Amherst, Mass.
Fiske, W. F., Agricultural Experiment Station, Durham, N. H.
Fletcher, James, Central Experimental Farm, Ottawa, Canada.
Forbes, S. A., University of Illinois, Urbana, Ill.
Forbush, E. H., 13 Stanwood Hall, Malden, Mass.
Fowler, Carroll, Agricultural Experiment Station, Berkeley, Cal.
Frost, H. L., 21 South Market street, Boston, Mass.
Garman, H., Agricultural Experiment Station, Lexington, Ky.
Gibson, Arthur, Central Experimental Farm, Ottawa, Canada.
Gifford, John, Mays Landing, N. J.
Gillette, C. P., Agricultural Experiment Station, Fort Collins, Colo.
Gossard, H. A., Agricultural Experiment Station, Lake City, Fla.

- Gould, H. P., Agricultural Experiment Station, College Park, Md.
 Hargitt, C. W., Syracuse University, Syracuse, N. Y.
 Harrington, W. H., Post-Office Department, Ottawa, Canada.
 Hart, C. A., University of Illinois, Urbana, Ill.
 Hillman, F. H., Agricultural Experiment Station, Reno, Nev.
 Hine, J. S., Ohio State University, Columbus, Ohio.
 Hopkins, A. D., Agricultural Experiment Station, Morgantown, W. Va.
 Howard, L. O., U. S. Department of Agriculture, Washington, D. C.
 Hudson, G. H., Normal and Training School, Plattsburg, N. Y.
 Hulst, G. D., 15 Himrod street, Brooklyn, N. Y.
 Hunter, S. J., University of Kansas, Lawrence, Kans.
 Johnson, W. G., Agricultural Experiment Station, College Park, Md.
 Kincaid, Trevor, University of Washington, Seattle, Wash.
 King, George B., Lawrence, Mass.
 Kirkland, A. H., Malden, Mass.
 Lowe, V. H., Agricultural Experiment Station, Geneva, N. Y.
 Luger, Otto, Agricultural Experiment Station, St. Anthony Park, Minn.
 McCarthy, Gerald, care of Crop Pest Commission, Raleigh, N. C.
 Mann, B. P., 1918 Sunderland Place, Washington, D. C.
 Marlatt, C. L., U. S. Department of Agriculture, Washington, D. C.
 Morgan, H. A., Agricultural Experiment Station, Baton Rouge, La.
 Mosher, F. H., 283 Pleasant street, Malden, Mass.
 Murtfeldt, Miss M. E., Kirkwood, Mo.
 Newell, Wilmon, Agricultural Experiment Station, Wooster, Ohio.
 Niswander, F. J., 2121 Evans street, Cheyenne, Wyo.
 Osborn, Herbert, Ohio State University, Columbus, Ohio.
 Packard, A. S., 115 Angell street, Providence, R. I.
 Palmer, R. M., Victoria, British Columbia.
 Pergande, Th., U. S. Department of Agriculture, Washington, D. C.
 Perkins, G. H., Agricultural Experiment Station, Burlington, Vt.
 Pettit, R. H., Agricultural Experiment Station, Agricultural College, Mich.
 Phillips, J. L., Agricultural Experiment Station, Blacksburg, Va.
 Popenoe, E. A., 303 Fillmore street, Topeka, Kans.
 Quaintance, A. L., Agricultural Experiment Station, Experiment, Ga.
 Rane, F. W., Agricultural Experiment Station, Durham, N. H.
 Reed, E. B., Esquimaux, British Columbia.
 Rolfs, P. H., Agricultural Experiment Station, Clemson College, S. C.
 Rumsey, W. E., Agricultural Experiment Station, Morgantown, W. Va.
 Sanderson, E. Dwight, Agricultural Experiment Station, Newark, Del.
 Saunders, William, Dundas street, London, Ontario.
 Schwarz, E. A., U. S. Department of Agriculture, Washington, D. C.
 Scott, W. M., Atlanta, Ga.
 Sherman, Franklin, jr., care of Crop Pest Commission, Raleigh, N. C.
 Simpson, C. B., Cornell University, Ithaca, N. Y.
 Sirrine, F. A., Agricultural Experiment Station, Jamaica, N. Y.
 Skinner, Henry, 716 North Twentieth street, Philadelphia, Pa.
 Slingerland M. V., Agricultural Experiment Station, Ithaca, N. Y.
 Smith, J. B., Agricultural Experiment Station, New Brunswick, N. J.
 Snow, F. H., University of Kansas, Lawrence, Kans.
 Southwick, E. B., Arsenal Building, Central Park, New York, N. Y.
 Stedman, J. M., Agricultural Experiment Station, Columbia, Mo.
 Stimson, James, Watsonville, Cal.
 Summers, H. E., Agricultural Experiment Station, Ames, Iowa.
 Test, F. C., 4048 Indiana avenue, Chicago, Ill.
 Thaxter, Roland, 3 Scott street, Cambridge, Mass.

Toumey, J. W., Yale Forest School, New Haven, Conn.
 Townsend, C. H. T., U. S. Custom-House, El Paso, Tex.
 Walker, C. M., Agricultural Experiment Station, Amherst, Mass.
 Washburn, F. L., University of Oregon, Eugene, Oreg.
 Webster, F. M., Agricultural Experiment Station, Wooster, Ohio.
 Weed, C. M., Agricultural Experiment Station, Durham, N. H.
 Weed, H. E., Griffin, Ga.
 Wilcox, E. V., U. S. Department of Agriculture, Washington, D. C.
 Woodworth, C. W., Agricultural Experiment Station, Berkeley, Cal.

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 Cholodkowsky, Prof. Dr. N., Institut Forestier, St. Petersburg, Russia.
 Cotes, E. C., 201 Ifley road, Oxford, England.
 Danysz, J., Laboratoire de Parasitologie, Bourse de Commerce, Paris, France.
 Enock, Fred., 13 Tuinell Park road, Holloway, London, N., England.
 French, Charles, Department of Agriculture, Melbourne, Australia.
 Froggatt, W. W., Department of Agriculture, Sydney, New South Wales.
 Fuller, Claude, Department of Agriculture, Pietermaritzburg, Natal, South Africa.
 Giard, A., 14 Rue Stanislaus, Paris, France.
 Goding, F. W., Newcastle, New South Wales.
 Grasby, W. C., Grenfell street, Adelaide, South Australia.
 Green, E. E., Royal Botanic Gardens, Punduloya, Ceylon.
 Helms, Richard, 136 George street, North Sydney, New South Wales.
 Horvath, Dr. G., Musée Nationale Hongroise, Budapest, Austria-Hungary.
 Lampa, Prof. Sven, Statens Entomologiska Anstalt, Albano, Stockholm, Sweden.
 Lea, A. M., Department of Agriculture, Hobart, Tasmania.
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 Lounsbury, Charles P., Department of Agriculture, Cape Town, South Africa.
 Mally, C. W., Department of Agriculture, Cape Town, South Africa.
 Marchal, Dr. Paul, 16 Rue Claude Bernard, Paris, France.
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 Urich, F. W., Victoria Institute, Port of Spain, Trinidad, West Indies.
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BULLETIN No. 27.—NEW SERIES.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY.

SOME INSECTS

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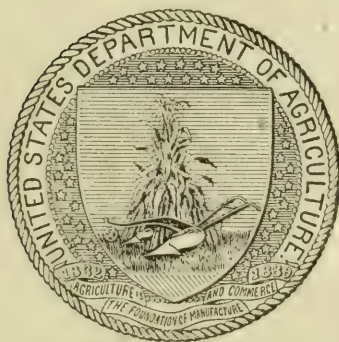
THE VIOLET, ROSE, AND OTHER ORNAMENTAL PLANTS.

A COLLECTION OF ARTICLES DEALING WITH
INSECTS OF THIS CLASS.

PREPARED UNDER THE DIRECTION OF THE ENTOMOLOGIST,

BY F. H. CHITTENDEN,

ASSISTANT ENTOMOLOGIST.



234755

WASHINGTON:
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1901.

DIVISION OF ENTOMOLOGY.

Entomologist: L. O. Howard.

First Assistant Entomologist: C. L. Marlatt.

Assistant Entomologists: Th. Pergande, F. H. Chittenden, Frank Benton.

Investigators: E. A. Schwarz, D. W. Coquillett.

Assistants: R. S. Clifton, Nathan Banks, F. C. Pratt, Aug. Busck, Otto Heidemann,
A. N. Caudell, J. Kotinsky.

Artist: Miss L. Sullivan.



VIOLET LEAVES, SHOWING INJURY BY THE GREENHOUSE LEAF-TYER—NATURAL SIZE.

(From photograph by P. H. Dorsett.)

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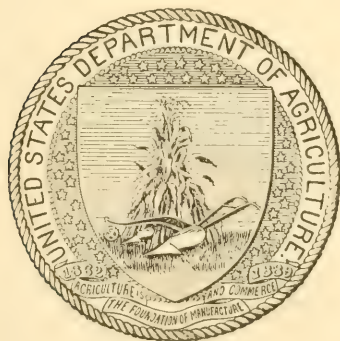
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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,

Washington, D. C., April 2, 1901.

SIR: I have the honor to submit herewith manuscript of a paper entitled *Some Insects Injurious to the Violet, Rose, and Other Ornamental Plants*, which has been prepared with admirable care and thoroughness by Mr. F. H. Chittenden, of this Division. The subject is one which has engaged Mr. Chittenden's attention for some time, and the investigation was necessitated by a very general complaint of damages by insects from growers of hothouse plants. The general subject is one which has not heretofore been treated, and the work is unquestionably needed. I recommend its publication as Bulletin No. 27, new series, of this Division.

Respectfully,

L. O. HOWARD, *Entomologist.*

Hon. JAMES WILSON,

Secretary of Agriculture.

PREFACE.

Within the past three years insect injury to violets grown under glass has been very pronounced and has been the occasion of considerable correspondence and investigation in this Division and of experiment in the line of remedial treatment, conducted chiefly by the Division of Vegetable Physiology and Pathology of this Department. Messrs. A. F. Woods and P. H. Dorsett, of that Division, were in charge of this work, and the latter gentleman, who is also a practical florist, has furnished much material for the investigations conducted at this office. The insects which have been the occasion of the principal injury and which have received the larger share of attention in the present bulletin are five in number: (1) The caterpillar of a small moth, which we have called the greenhouse leaf-tyer; (2) the larva of a hymenopteron, which will be called the violet sawfly; (3) a plant-louse undescribed at the time work was begun on this class of insects and known to violet growers as the black or brown aphid or "black fly;" (4) the common "red spider," and (5) a small maggot called by florists the "gall fly." Several instances of injury by the larva of the moth above mentioned, to violets and other greenhouse plants, have been published; and the red spider is altogether too well known as a pest everywhere. None of these species has been at all fully treated biologically and economically in any of the publications in which they have hitherto been considered, and none has been figured in Departmental publications with the exception of the gall fly, which was described specifically in an earlier bulletin of this series. Numerous other insects have been observed upon violets in recent years, and some have been sent in by correspondents, particulars concerning which will be given. Certain common greenhouse pests other than those which will receive special mention, such as white grubs, wireworms, and sow-bugs, are occasionally troublesome to violets. Several species of cutworms have been observed from time to time attacking violets, and these will be considered with such other insects as have been recorded in our Divisional notes and in literature as occurring on this genus of plants.

Several other species of greenhouse pests, notably such as infest the buds and blossoms of roses, have been conspicuous in recent years, and certain of the more interesting of these will be duly considered in accordance with their injuriousness. Prominent among these are

little caterpillars known as rose leaf-tyers, rose gall flies (minute maggots, similar to those which attack violets), bud-worms, etc.

It was found impossible to complete certain of the studies planned and begun in 1898, owing to the scarcity of material (about Washington) the following years, but it is believed advisable not to further delay publication, as it is impossible to foretell when sufficient material will be available for our purposes.

Since the writer is not a special student of Lepidoptera he has preferred to use in the present work the lepidopterous genera in Smith's Catalogue rather than to adopt those recently proposed by certain European systematists, among whom is Sir G. F. Hampson, who has been for some time engaged upon the *Pyrilidæ*. By so doing he believes that a certain degree of unnecessary confusion will be avoided, as it is by no means certain that the new generic arrangement of the European lepidopterists will be generally adopted in toto by Americans; and, until this matter has received the attention which is its due on the part of our students of this order, the old genera will be retained.

Mr. B. T. Galloway, Director of Plant Industry, has discussed some of the principal insect pests of the violet in a little handbook, published in 1899, on the subject of growing and marketing violets for profit, and entitled "Commercial Violet Culture." The question of violet insects with the remedies to be employed against them is considered on pages 190-215 of that publication.

In the present bulletin all of the text figures designated as original have been drawn by Miss Lillie Sullivan, under the writer's personal supervision, and for the most part from selected fresh material.

F. H. C.

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SOME INSECTS INJURIOUS TO THE VIOLET, ROSE AND OTHER ORNAMENTAL PLANTS.

THE GREENHOUSE LEAF-TYER.

(*Phlyctænia rubigalis* Guen.)

One of the most troublesome of all known enemies of violets and other ornamental plants when once it obtains foothold in a conservatory is the greenhouse leaf-tyer, the larva of a small moth, now known as *Phlyctænia rubigalis* Gn., but formerly as *P. ferrugalis* Hbn.

Until within recent years only a few instances of injury by this species had come to our knowledge or been brought to public notice. During the past four years, however, its depredations have attracted attention in widely separated localities, and it is evident that this insect has now become established as a pest more than periodically injurious. As such it is entitled to somewhat extended notice. The greenhouse leaf-tyer, as its name would suggest, is more particularly annoying to ornamental plants grown in greenhouses; but its injuries do not cease here, since the larvæ work also in the field—celery, beets, cabbage, and tobacco, among crop plants, being most often affected.

NATURE OF INJURY.

The usual manner of work of the larva is upon the underside of a leaf. A fair specimen of larval injury to violets is shown in Plate I, which is reproduced from a photograph. The leaves figured were eaten out in holes on the under surface, leaving the upper epidermis intact, and this is the manner of injury to many other plants. Some plants, however, are eaten entirely through and some are skeletonized. Occasionally larvæ, when numerous, feed upon the upper surfaces of the leaves, but this is exceptional. The normal habit of the larva in feeding is to fasten together two contiguous leaves, to curl over the edge of a single leaf upon which it may be feeding, or to spin about itself a thin, filmy web within which to feed.

In close confinement a few larvæ will in a very short time devour and destroy their food plant. In one experiment in rearing this species at this office, larvæ completely destroyed a large pot of violets in ten days.

DESCRIPTION OF THE SPECIES.

The moth which produces the greenhouse leaf-tyer is a member of the family Pyraustidae, superfamily Pyralidina, and was first recognized and described from this country in 1854 (Guenée, *Deltoides* et *Pyralites*, p. 398). It is an inconspicuous little pale reddish-brown species

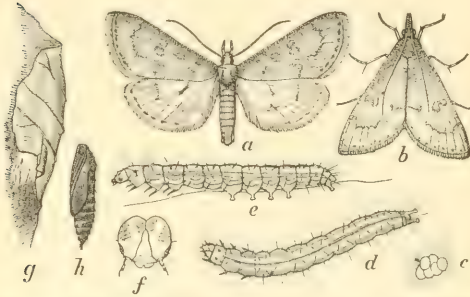


FIG. 1.—*Phlyctenia rubigalis*: a, moth; b, same in natural position at rest; c, egg mass; d, larva from above; e, same from side; f, head of same; g, pupa case; h, chrysalis—a, b, d, e, g, h, one-half larger than natural size; c, twice natural size; f, more enlarged (original).

with a wing expanse of about three-fourths of an inch. The fore-wings are light clay brown in color, suffused with a slightly darker reddish or ochreous brown, the serrate blackish lines with which they are ornamented forming the pattern shown in the accompanying illustration (fig. 1, a). The hind-wings are gray, becoming light brownish toward the termen, and with two discal

spots, the costal one prominent. Both wings are bordered with a row of small well-defined black dots.

The description of the moth by Mr. A. R. Grote, which appeared in 1877 under the name of *Botis harveyana* (Can. Ent., vol. IX, p. 104), is copied herewith for the further identification of the species:

A small species more slender than *communis*,¹ with pale, brown primaries, the exterior line fine, blackish, obsoletely denticulate, rather suddenly drawn in at vein 2, thence back again and angulate before the margin. Outer spot large, annulate. Inner spot obsolete. Before the fringes, which are faintly interlined with pale and are discolorous, there is a distinct sinus of dark points. Hind-wings paler than primaries, washed outwardly with the same brown as primaries, with a distinct discal dot and median line. Beneath more ochreous, with the discal dots double on hind-wings; a common exterior line; on the primaries the veins are partially darker marked; terminal points very distinct and continuous. Head, palpi, and thorax above pale-brown, beneath concolorous with under surface of wings glistening.

Dimensions: Fore-wings, 17–20^{mm}; hind-wings, 14.5–17^{mm}; length of body, 7.5–10^{mm}.

The venation and the shape of the head and antennae is about as in *P. ferrugalis* shown in figure 2.

The moth bears a strong superficial resemblance to the common

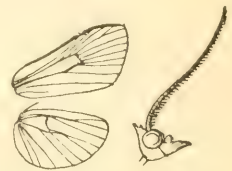


FIG. 2.—*Pionca ferrugalis*: wing venation of moth at left; side view of head at right—enlarged (after Hampson).

¹ Presumably *Botis communis* Grt. (Can. Ent., v. VIII, p. 99=*Loxostege similalis* Gn.

garden webworm, *Loxostege* (*Phlyctanodes*) *similalis* Guen., but may be distinguished by the characters above given. That there need be no confusion of identity an illustration of this latter is also introduced for comparison (fig. 3).

NOMENCLATURE AND SYNONYMY.

Since the original description of Guenée in 1854 (l. c.) which appeared under the genus *Scopula*, the species has been described under the names *Botys oblongalis* Led. (Wien. Ent. Monatschrift, 1863, pp. 372, 469), as well as *Botis harveyana* Grt., and assigned to various other genera among which are *Margaritia*, *Phlyctænia*, *Pyrausta*, and *Pionea*.

In domestic lists and current literature this species has usually been mentioned as *Phlyctænia ferrugalis* Hbn., but it is at present catalogued by Sir G. F. Hampson (Proc. Zool. Soc. London, Feb. 21, 1899, p. 242) as *Pionea rubigalis* Guen. According to the usage of American systematists this species appears to belong rightfully to *Hapalia* Hbn., a genus which was proposed, though not described, as early as 1827, or twenty-seven years before Guenée's genus *Pionea*.

Phlyctænia rubigalis is, according to Hampson, native to North America and distinct from the Old World, and nearly cosmopolite *ferrugalis* Hbn.,¹ with which it has until very recently been confounded.

DISTRIBUTION OF THE SPECIES.

Grote's types of *Botis harveyana* were from New York and Texas. In the National Museum are specimens bearing capture labels of Illinois, 1876, and St. Louis, Mo., 1878. Published records and specimens now in the National collection are in evidence to show that the known distribution, though not cosmopolitan, is very wide, covering nearly our entire country from Canada to the Gulf States and from the Atlantic to the Pacific. The following are the known localities:

Toronto, Canada; Wading River, L. I.; Albany (Lintner), Poughkeepsie, Highlands, New York City, and Ithaca, in New York; Libonia, Pa.; New Jersey—throughout the State (J. B. Smith); Lakeland, Kensington, and Garrett Park, Md.; Tennallytown and Brook-

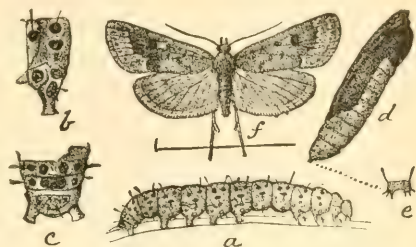


FIG. 3.—*Loxostege similalis*: a, larva; b, side view of middle segment of larva; c, dorsal view anal segment of larva; d, pupa; e, cremaster of pupa; f, moth—a, f, somewhat enlarged; d, twice natural size; b, c, e, more enlarged (from Riley in Ann. Rept. Dept. Agr., 1885).

¹This latter species is recorded from central and southern Europe, Great Britain and Ireland, Western Asia, India, Ceylon, Burma, Japan, Afghanistan, western and southern Africa.

land, D. C.; Louisa County, Va.; Harpers Ferry, W. Va.; Wooster and elsewhere in Ohio; Indiana; Pekin, Urbana, (Forbes and Hart), Chicago, and central parts of Illinois; Kalamazoo, Mich.; North Carolina; Texas (Belfrage); Key West, Fla.; St. Louis, and central part of Missouri; Alameda (A. Koebeler) and Los Angeles (Coquillett), Cal.

The fact of this species being so well established as a greenhouse pest and preferring indoor life to that of the field, is at least strongly suggestive of exotic and even tropical origin. From the above list of localities it will be seen that it occurs from semi-tropical portions of Florida through the Lower and Upper Austral life zones to what is at present considered Transition. For a species of its habits there is no reason why it should not become established, at least in greenhouses, still farther north in colder latitudes.

THE EGG AND OVIPOSITION.

Eggs are deposited singly or in masses of from two to nine or more; when laid in groups the different eggs composing it overlap as shown in the illustration (fig. 1, *c*). Many such groups may sometimes be found under a single leaf.

The egg.—The egg is scale-like in appearance; when first laid, clear grayish white in color, and so nearly translucent as to show the color of the surface, e. g., the green of a leaf, upon which it is deposited; the exterior surface shining glassy and iridescent; flattened upon the surface of deposition; convex above and somewhat variable in outline but usually broadly ovate. The surface is rather strongly and rather finely rugose, irregularly subreticulate. The average length is about 0.8^{mm} and the width 0.65^{mm} .

THE LARVA AND PUPA.

The full-grown larva.—The larva when full grown presents the appearance indicated by *c* and *d* of figure 1. It is green or greenish yellow in color and somewhat translucent; the head is whitish and rather faintly spotted with small purplish spots (fig. 1, *f'*), and the first thoracic segment is marked on each side by a small but conspicuous round black dot. Along the dorsum the green ground color of the body shows as a narrow, rather conspicuous median green line, and on each side of this is a double line of white. The legs show on their outer surface two little round black dots and the prolegs are rather long and prominent. The surface is very sparsely hairy. The mature larva, when extended at full length in natural feeding position, is nine or ten times as long as wide, measuring about three-fourths of an inch ($18\text{--}20^{\text{mm}}$) in length and only about a twelfth of an inch in width (2^{mm}).

The pupa.—The pupa is dark, shining brown, and bears along its dorsal surface conspicuous hairs, as shown in the illustration (fig. 1) at *h*. It measures about three-eighths of an inch in length (7.5^{mm}).

Owing to the fact that the identity of this species with the closely related European *Phlyctania ferrugalis* Hbn., which has been very carefully studied and described in detail in its several stages by the Rev. William Buckler in The Entomologist's Monthly Magazine for February, 1878 (pp. 200-204), was not for a moment doubted, no effort was made to watch the various molts or to make detailed descriptions of the larvæ while these could be obtained in fresh condition for the purpose. When the specific distinctness of the two species was recognized on receipt of the publication of Sir G. F. Hampson, previously cited, it was not possible, owing to the lateness of the season, to secure sufficient material for rearing.

The development of the embryo in the egg has been observed by Buckler in the case of the European species, and probably this does not differ much in the case of our own species. He states that the margin of the egg on the seventh or eighth day "becomes rounded or raised, and, like the rest of the upper surface, a little convex; the shell then is seen to be minutely pitted, and through it the whitish, wax-like, opaque, faint form of the larva coiled round can be just discerned; on the ninth day it shows more distinctly, and on the tenth the head can be plainly seen as a black spot on the margin; the shell is pearly and glistening; and after this the larva hatches in a few hours."

LITERATURE OF THE SPECIES.

The first notice that the writer finds which bears upon the biology of this insect was published in 1890 in the form of abstracts from correspondence in Insect Life (Vol. II, p. 277), further mention of which will be made under the heading of "Divisional Records of Injury." The species is there referred to *Botis harveyana* Grote.

In 1893 Mr. G. C. Davis gave a short popular account of this moth, with original illustrations of its different stages, in Bulletin No. 102 of the State Agricultural College of Michigan (pp. 28, 29).

In his report on the insect injuries in Maryland in 1897, Prof. W. G. Johnson mentions the finding of the larva injuring the young and tender lower leaves of tobacco in a hotbed at the Maryland Agricultural Experiment Station (Bul. 9, n. s., Div. Ent., p. 83; Bul. 57, Md. Agl. Expt. Sta., p. 7). They were noticed in abundance from July 1, and most numerous July 13. In the Florists' Exchange for October 23 of the same year, Mr. P. H. Dorsett, of this Department, gives a few notes on this moth and its injuries to the leaves of violets, illustrated with a half-tone reproduction of a photograph of the insect, natural size, in its different stages and its work.

It should be added that Mr. Dorsett met with this insect also at Poughkeepsie and Highlands, N. Y., and he informs the writer that it was troublesome in greenhouses there and elsewhere along the Hudson River valley.

The same year Mr. James S. Hine published a very good three-page account of this species, with original observations upon its life history, in the Columbus Horticultural Journal (reprint, dated September 28, 1897, pp. 1-4).

In the edition of the Weekly Florists' Review, of Chicago, Ill., for March 3, 1898, the writer published a short preliminary account of this insect in answer to the inquiry of a correspondent of the Review, who requested a reply through the columns of that periodical.

Under the heading *Phlyctania ferrugalis* Mr. Galloway mentions this species on pages 214 and 215 of his work "Commercial Violet Culture," published in 1899, giving a half-tone illustration of the insect and its injury, from photographs of the same.

This species was included in a list of the principal injurious insects of the year 1899, with brief mention of reported injury to violets in Maryland and Virginia and to other greenhouse plants in New York and Canada, in the Yearbook of the United States Department of Agriculture for 1899 (1900), page 746.

It has also received brief mention under the name of the chrysanthemum leaf-skeletonizer in a paper entitled Insects Infesting Carnations, by F. A. Sirrine, published in the American Florist for March 3, 1900 (Vol. XV, p. 912). Chrysanthemums were stated to be subject to attack particularly when roses were grown in the same house.

In Bulletin No. 60 of the University of Illinois Agricultural Experiment Station, also published in 1900, Messrs. Forbes and Hart have a short article on this species (pp. 453, 454), which was found attacking beets at Urbana and near Pekin, Ill.

In a recent publication by Dr. James Fletcher (Transactions Royal Society of Canada, Vol. V, second series, 1899-1900, p. 228) mention is made of this leaf-tyer in connection with its occurrence in Canada upon the leaves of roses in greenhouses. It was reported to have done very serious damage three years previous to the time of publication, necessitating the entire cleaning out of a large house of choice roses. In the same writer's report, as entomologist and botanist to the Canada department of agriculture, central experiment farm, for 1899 (1899), pages 179, 180, and in the Report of the Entomological Society of Ontario, for 1899 (1900), page 110, more detailed accounts of this same attack are given, with notes.

Mr. Davis has called this insect the celery borer, from the habit of the larva of boring into celery stems; but this habit is evidently an exceptional one, as it is normally a leaf-feeder, and, although its habits vary, it usually joins together the leaves of the plant upon which it feeds. It appears to feed by preference also upon the terminal leaves of most plants and upon such plants as are growing in dark or protected situations. As the species is omnivorous and, so far as observed, a pest chiefly in greenhouses, the writer some time ago proposed the

name of greenhouse leaf-tyer, a cognomen which has already been adopted.

DIVISIONAL RECORDS OF INJURY.

What is probably the first rearing of this species is that of June, 1888, in the laboratory of this office. The 23d of that month Mr. Theo. Pergande found larvæ and pupæ in one of the conservatories connected with this Department. They had done much damage to a number of small plants of the nodding thistle, *Carduus* [*Alfredia*] *cernuus*, a European plant sparingly introduced about some cities in the Eastern United States. These larvæ had completely skeletonized the plants, causing them to dry up. From this lot moths were reared June 28. On September 14 of the same year were received larvæ and pupæ from Mr. E. S. Miller, Wading River, Queens County, N. Y., with the statement that the larvæ were doing much injury to all kinds of "soft-wooded" greenhouse plants (Insect Life, Vol. II, p. 277).

The writer's first experience with this species was on July 7, 1893, when it was observed in all stages in a conservatory at the World's Columbian Exposition at Jackson Park, Chicago. One of the exhibitors in the Horticultural Building showed the writer specimens of the moth, and stated that it was very injurious to dried apples from Missouri and Idaho. A personal visit to the building resulted in the discovery that the dried apples were, in reality, injured by the Indian-meal moth (*Plodia interpunctella* Hbn.); but by striking some of the ornamental plants in the conservatory with a cane the moths of this leaf-tyer were induced to fly up and were captured. A careful search of the plants upon which the moths were most frequently noticed led to the finding of the larvæ. The plants mostly attacked were the wandering jew (*Tradescantia zebrina*), ground ivy (*Nepeta glechonina*), and geranium, the last being least affected. It was noticed that the larvæ fed chiefly upon the terminal leaves, and, for the most part, on the under surface. They were surrounded usually by a slight silken web, and where two leaves were in contiguity they were often fastened together with the silk, and sometimes a single leaf would be folded. Unfortunately, observations were not carried on as intended, owing to the fact that the exhibitors having charge of the conservatory evidently became suspicious of the frequent visits of a "Government official," and, no doubt, fearing that publicity might be given of the facts in the case, kept a sharp lookout for insects of every kind, and destroyed every insect in sight. Mention is made of this fact because it resulted in a test of a good but somewhat tedious remedy. August 7 only a single moth could be found and no larvæ. Soon after the writer's first visit in July the attendants trimmed the infested plants and they were afterwards trimmed as often as the larvæ showed themselves. As already stated, the larvæ affect more especially the terminal leaves of

these particular plants, and these were destroyed after being cut off, presumably by being crushed under foot. One of the attendants stated that the plants had also been dosed with a strong tobacco wash, which probably affected such larvæ as might have remained on the plants.

July 23, 1897, Mr. F. C. Pratt found numerous individuals of the moths as well as larvæ on celery at Brookland, D. C. An average of about three pupæ were found spun up in the leaves at the tops of all the young plants, and when the plants were brushed with a stick or by hand the moths "rose up in clouds." The owner of the place where the insects were at work stated that this species had been a most troublesome pest the previous year; its habit of feeding upon the tops of the celery greatly lessened its market value. It was his first year in celery raising in that locality, and he had conceived the idea that it would not be profitable to raise that crop there. In succeeding years, however, there was a decided decrease in the numbers of this leaf-tyer. When the place was visited by the writer in 1899 and in 1900 the insects were comparatively rare.

During January and February, 1898, this species was the subject of correspondence between this Division, the Florists' Review, of Chicago, Ill., and Mr. Robert Mearns, a florist, of Toronto, Canada. The latter sent specimens in all stages, with the report that this insect was doing much damage to plant life in the greenhouses of some of the florists in that city. The florists were very anxious to learn of an effective remedy for the pest. Larvæ were particularly destructive to heliotrope, wallflower, violet, and geranium.

April 28, specimens of the moth and pupa of the greenhouse leaf-tyer were sent to this office by Mr. S. S. Wilson, Libonia, Franklin County, Pa., with the statement that the larva was very injurious to greenhouse plants, such as geraniums and dahlias. From this lot one moth was obtained April 30. May 17, the same gentleman made another sending of material and, in response to inquiry, furnished a list of the plants affected in his greenhouses. This list includes *Ageratum*, geranium, German ivy, Kenilworth ivy, ground ivy, dahlia, *Justicea*, chrysanthemums, *Cineraria hybrida*, anemone, cabbage, *Matricaria*, *Passifloras*, *Plumbago*, *Ruellia*, *Tydaea*, daisy, *Lobelia*, *Veronica imperialis*, *Lantana* and *Deutzia*. Larvæ were first noticed at that place about the 1st of January, in 1898, on *Ageratum* in a hot place in one of the greenhouses, and next upon geraniums. At the time of this writing it was feared that if their ravages were not checked they would eat all the near-by plants. It was noticed that they had a special fondness for forming their cocoon-like pupal cases on *Anemone japonica*.

May 14, 1898, Mr. Pratt called the writer's attention to the great numbers of the moths of this species that were present in a large field of rhubarb at Tennallytown, D. C. When the field was visited again on the 17th it was found that this was by far the most abundant spe-

cies of moth then present in that locality. They began hovering about the plants before sundown, often several individuals being in sight at one time. A considerable proportion alighted upon the rhubarb leaves and immediately crawled to the lower surface and disappeared when not molested, while others alighted upon clover and weeds in the same field.

Again the following year moths were observed in the same fields and elsewhere early in the season, but careful search failed to reveal any larvæ. The only wild plant from which the species has been reared here is hedge mustard (*Sisymbrium officinale*). Imagos issued June 10-17.

Attack upon field crops and weeds, aside from celery, is not so obvious as in the greenhouse, the larvæ being distributed here and there in such manner that they can do little harm. Hence it follows that larvæ are rather rarely found out of doors, though the abundance of the moths show that they undoubtedly are present and often in some number, on a great variety of crop plants and weeds.

Later in the season of 1899 the species when sought for was rarely found. Mr. Dorsett was able to obtain only three larvæ from his violet greenhouse, and search by the writer in several beds of celery failed to be productive of many individuals.

November 15, 1899, Hon. G. W. Koiner, Richmond, Va., sent specimens of this species, among others, that were depredating on violet beds in Louisa County of that State.

January 12, 1900, Mr. Franklin Sherman, jr., wrote that this species was breeding at Ithaca, N. Y., on a great variety of plants, and had made itself quite a serious pest in the forcing houses during that winter.

In a letter of the same date Dr. James Fletcher reported attack by this species in greenhouses in Canada.

The foregoing mention includes only such plants as the larvæ have been found to select for themselves. In confinement, larvæ, after devouring the potted plants upon which the eggs had been deposited, were fed with bean leaves, which happened to be the most available plants on which to feed them at the time. It appears probable that larvæ would thrive on almost any succulent vegetation, with perhaps the exception of conifers.

In addition to the plants above mentioned, there is a Divisional record of this moth having been reared from some species of ragweed or pigweed (*Ambrosia*) from central Illinois.

HABITS OF THE LARVA.

Soon after hatching, the larva begins feeding, at first cutting little patches of parenchyma from the under surface of the leaves, leaving the upper epidermis intact, as shown in the illustration of an affected

violet plant in Plate I. A few days later it usually seeks concealment by drawing together by means of its fine silken webbing portions of a leaf or of two leaves that happen to be contiguous.

The terminal leaves of such creeping plants as the wandering jew appear most subject to attack, while the lower leaves of taller plants are most injured. As in the case of many other greenhouse insects, the larvæ prefer secluded places, and plants growing in shady locations are most affected.

When full grown the larva prepares for pupation in different ways. Sometimes it will spin up between two leaves, but more often rolls up a pupa case at the edge of a leaf, if the leaf be large, cutting a slit usually on one or both sides before drawing the leaf over itself. The interior it lines with a thin silken membrane, and within the cocoon thus formed changes to pupa. In figure 1, *g*, a pupal case showing slit on one side is illustrated.

Individuals that were observed in May would be feeding one day and the next would form their pupa case and the same or the next day would transform.

HABITS OF THE MOTIL.

As has already been stated, the moths fly just before sundown. Indoors they rest during the daytime on the lower surface of the leaves of their food plants and other low-growing plants and doubtless remain thus for many hours at a time unless disturbed. When disturbed they fly only a very short distance before they alight and at once seek the underside of a leaf again. They fly low and if along the ground they alight only to again fly up until the underside of a leaf is found. In these habits they resemble many other moths that could be mentioned. The position taken by the moth when at rest on the under surface of a leaf is shown in figure 1, *b*.

DEVELOPMENT AND GENERATIONS.

It will be noted, in Buckler's account of the development of the egg of the European *Phlyctenia ferrugalis*, that hatching took place on the tenth day. With our native leaf-tyer, eggs that were found on rolled violets in a rearing jar in which moths had been placed May 11, and which were presumably laid on that date, hatched May 23, or in twelve days.

The oldest larvæ of this lot attained full growth and began crawling about the rearing jar, June 10; on the 11th began spinning, and on the following day had pupated, thus giving twenty days as the duration of the larval stage. The individuals which developed into pupæ June 12, transformed to imago June 19, giving seven days as the duration of the pupal period for this time of the year. The weather averaged about normal, the temperature being 75-86° F.

The duration of the first generation observed was therefore thirty-nine days.

There is little doubt that in confinement a generation of this species is produced which issues in April and May. The writer, therefore, feels justified in considering the first generation reared at this office as the second indoor one. Of the development of the first generation, then, nothing can be said.

A larva from the hypothetical first generation was observed to begin the construction of its pupal case May 13, on the following day it spun up and over night changed to pupa, the imago issuing during the night of May 23, the duration of the pupal period for this individual having been nine days. A second individual went through this process in the same time, beginning to spin up May 16, completing its work the following day, being found as pupa next day and issuing as adult on the 27th; the weather was cool. In hot August weather the pupal condition consumed seven days.

The midsummer generation, as observed at this office, may be passed in thirty-four days; or, we may say, in about five weeks. The egg state required but five days, and this with the pupa seven, leaves twenty-two days or about three weeks for the larval period.

In an exceptionally low temperature in which a midwinter generation was reared under artificial conditions, neither that of a conservatory nor the field, where the temperature varied from 42° to 62° F., eggs laid January 19 hatched thirty-four days later, or in about five weeks. The larval period was prolonged about two weeks, and the imagoes, which laid the eggs in this experiment lived, some of them, a month, and one for six weeks.

The larva has been traced through its molts by Mr. Hine, at Columbus, Ohio (l. c.). In greenhouses he found that the larva makes its first molt in eight days after hatching, and at intervals of about five days thereafter, having four molts in all, the duration of the last stage—that is, after the fourth molt—being about eight days. The duration of these molts in a close conservatory in hot weather would, of course be a day or two less.

Two and probably more generations are unquestionably produced annually in the open, and in hothouses a still greater number. At least four are indicated for the average indoor temperature of a conservatory.

On this head, Mr. Hines says: "It is evident that at least five generations are produced in the interval between the middle of September and the middle of the following May, or the time during which most commercial greenhouses are in operation."

Divisional records and those of captures show that moths have been taken out of doors as early as April in central Illinois and central Missouri, and in May in the District. Moths have been reared under

more or less unnatural conditions, but similar to what are experienced in greenhouses in every month throughout the year.

LIST OF FOOD PLANTS.

The known host plants of this species may be summarized as follows: Celery, cabbage, beets, and tobacco, among crop plants; and of greenhouse and other ornamental plants, *Ageratum*, geranium, ground ivy (*Nepeta glechoma*), German and Kenilworth ivy, violet, heliotrope, wall flower, wandering Jew (*Tradescantia zebrina*), dahlia, daisy, Justicea, chrysanthemum, carnation, Cineraria, begonia, abutilon, roses, pelargonium, anemone, nasturtium, moonvine, Swainsonia, Genista, Plumbago, Matricaria, Passiflora, Ruellia, Tydea, Lobelia, Veronica, Lantana, Deutzia, nodding thistle (*Carduus*), and ornamental Ambrosia. Of weeds it has been observed on hedge mustard (*Sisymbrium officinale*) and ragweed (*Ambrosia*).

SUMMARY OF THE LIFE HISTORY.

The life history of the insect is now practically known, and the summary which follows is fairly complete. This species occurs out of doors, where it sometimes does considerable damage to celery, but aside from this its injuries are confined, for the most part, to plants in conservatories.

The moth lays its scale-like white eggs on the plant which is to serve as the food for its larvæ. The eggs hatch in from five days to about three weeks, according to temperature.

The larva, soon after it is hatched, usually conceals itself or begins the process of doing so by drawing together, by means of its white silken web, a portion of a leaf, or it thus joins two contiguous leaves and feeds upon their lower surface. The work of the larvæ has been most noticeable in secluded situations, and, on most plants, upon the terminal leaves, which they eat full of holes. They work chiefly at night, and by day rest in the same location; here also they transform to pupæ or chrysalides, and subsequently to the imago or moth state. Occasionally, at least, perhaps in the case of the hibernating generation out of doors, the larvæ seek more protected locations for their transformations.

Hibernation either begins in the larval state and ends toward the approach of warm spring weather with the pupa, or is passed in the pupal condition. In warm indoor temperatures there is no definite hibernating period.

The larval period varies also, according to the temperature at the time of transformation, from an observed minimum of about three weeks to perhaps five weeks, and the pupal period from one to probably two weeks.

NATURAL ENEMIES.

A single parasite of this species has been observed, the only natural enemy that appears to be known for it. Among a lot of larvæ from Libonia, Pa., a cocoon was found May 19, which gave the imago May 27. It was identified by Mr. Ashmead as a species of *Synetæris*, an ichneumonid genus related to *Limmeria*.

REMEDIES.

Hand-picking.—The greenhouse leaf-tyer can be controlled in greenhouses by hand-picking or trimming away and destroying all infested leaves or other portions of plants as often as they are detected. This has been successfully practiced in a number of cases, one of which has already been mentioned, but it is somewhat laborious. Mr. Wilson wrote in regard to this species that he entirely rid his greenhouse of it one season by hand-picking.

Attracting moths to lights.—Another method of checking the increase of the species is by attracting the moths to lights placed in the greenhouses at night. This method is in practice by at least one of our correspondents, who reports that it affords some relief. Lights to be most successful should be placed over vessels of water on which a thin scum of kerosene is floating.

In any case a careful lookout should be kept for this and other insects which injure the plant by eating its leaves.

Arsenical spray.—Paris green or other arsenical would, if applied at the outset of the attack, effect the destruction of the larvæ, but it has not been ascertained by practical experience whether or not such a spray would destroy the more mature larvæ. Owing to their more or less protected manner of working, it would probably not do so effectually. An underspraying is, of course, a necessity.

This and hand methods are about the only remedies applicable to celery beds and elsewhere out-of-doors. An objection to the use of Paris green on violets and some other greenhouse plants is that the plants have to be syringed every few days for protection against the so-called "red spider," and this would wash away the arsenite. Another is that a poisonous wash could not be used when the plants are in bloom. It might also injure the foliage of certain tender plants. It is better to use some remedy that will at the same time destroy other insects with which the greenhouse may be affected.

Tobacco as a greenhouse fumigant.—The most widely useful insecticide for greenhouse fumigation is tobacco in its various forms. In many instances it is without doubt the cheapest and safest insecticide to use against certain greenhouse insects, particularly plant-lice. Its effectiveness, however, under the best conditions is not great, as it

requires repeated use at short intervals. Moreover, it may cause serious injury to some plants. On the other hand, tobacco may prove injurious to the foliage and flowers of certain plants such as violets, by bringing on epidemics of "spot." Tobacco is also useless against scale insects in general and mealy bugs.

Hydrocyanic-acid gas treatment.—At present the most satisfactory manner of dealing with this and similar pests is by means of hydrocyanic-acid gas which has been developed as a medium for the fumigation of insect-infested greenhouse plants by the Division of Vegetable Physiology and Pathology of this Department, having been used under the direction of Mr. A. F. Woods in 1894, and later by Mr. Woods and by Mr. P. H. Dorsett. Detailed directions for its use were given by these two gentlemen in Circular No. 37, 2d Ser., of this Division, from which publication the directions which follow on the hydrocyanic-acid-gas method have been largely transcribed.

This remedy has proved particularly effective against the present species on violets and against aphides on similar greenhouse flowers, and has the advantage of being useful against all other insects except the so-called red spider, which it does not entirely destroy, but it can not yet be safely used for the fumigation of certain other plants owing to the danger of bleaching and otherwise injuring them; hence it will be wise, before undertaking fumigation on a large scale on other plants which will be mentioned, to first try this remedy experimentally on a few plants and in a small way.

THE HYDROCYANIC-ACID-GAS METHOD OF FUMIGATING GREENHOUSES AND COLD FRAMES.

Hydrocyanic-acid gas, since its introduction by the Division of Entomology in 1886 as a remedy against scale insects of the orange, has proved of great value as an insecticide. Previous to our experiments early in 1895, though it had been occasionally tried in greenhouses, hydrocyanic acid was not recommended on account of its injurious effects upon plants. As a result of a series of careful experiments we found that, as a rule, plants were less injured by a short exposure to a relatively large amount of gas than they were by a long exposure to a relatively small amount. On the other hand, a strong dose for a short time was the most effective in killing insects. Different species and varieties of plants, however, were found to vary remarkably in their power of withstanding the poison. This in many cases appeared to depend upon the open or closed condition of the breathing pores, as well as upon peculiarities of the cell contents. Fumigation an hour or two after sundown, with the temperature as low as practicable, was found to give the best results. In each case the proper amount of gas to use and the length of exposure must be determined by experiment. It is impossible at present to give a general rule applicable to all plants in all stages of development. When the conditions are once determined they must be strictly followed to insure the greatest success. Methods of experimenting will be described in the latter part of this circular. The quantity of gas in each case is always given in terms of the potassium cyanide from which it is made, and on a basis of a cubic foot of space, as will be explained more in detail further on. The cyanide, as well as the gas made from it, is exceedingly poisonous, and both must be used with the greatest care.

Ferns.—For *Davallia mooreana* infested with a scale insect (*Chionaspis* sp.), 0.075 gram of 98 per cent potassium cyanide should be used for each cubic foot of space to be fumigated, not deducting the space occupied by the plants. Length of exposure, twenty minutes.

One hundred and fifty to two hundred plants with fronds in all stages of development have been thus treated two or three times each year for the past four years with no injury to the plants and almost complete destruction of the insect. They were treated fifty at a time in a fumigating box (fig. 4.), described later.

Adiantum cuneatum and *A. Ballii* have been tried on a small scale and were not injured by the treatment.

Coleus.—"Golden Bedder," "Verschaffeltii," "Shylock," and others. 24,000 plants in pots, badly infested with the "white-tailed" mealy bug (*Orthezia insignis*). The house contained 15,587 cubic feet of space. Treated at the rate of one-tenth of a gram of 98 per cent cyanide of potash per cubic foot of space for twenty minutes, one hour after dark. *Orthezia* all killed and plants not injured in the least. All

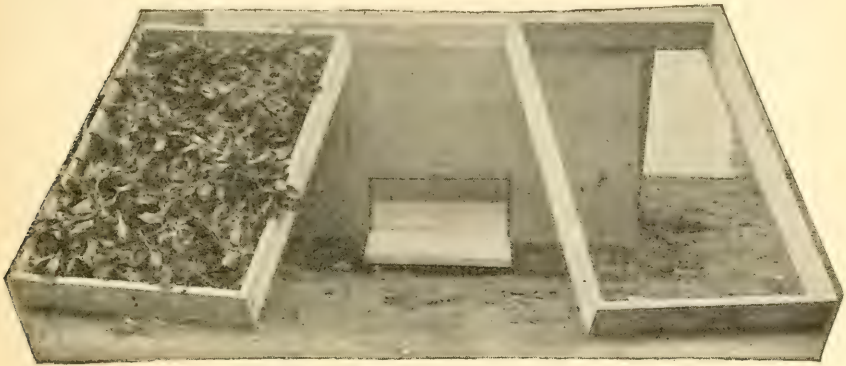


FIG. 4.—Fumigating box showing trays and coleus cuttings (from Woods and Dorsett).

other means of destroying the *Orthezia* had been tried without effect. Large numbers of the common mealy bug were also killed by this treatment; but it was not nearly so effective as for the "white-tailed" mealy bug. All coleus cuttings made by the United States Propagating Gardens for the past two years have been fumigated before being prepared for the cutting bed (see fig. 4).

Double English violets.—"Marie Louise," "Lady Campbell," and others. For plant-lice and general fumigation fifteen-hundredths of a gram of 98 per cent cyanide of potash for each cubic foot of space is required. The exposure, if made according to directions, will not hurt the plants in any stage of growth. The gas has been used on a large scale in fumigating violets for the past three years with the greatest success, only a few treatments during the season being required. Leaf-eating larvae, slugs, millipedes, cutworms, etc., when exposed are killed as well as plant-lice. Red spiders, however, are not entirely eradicated by the treatment. The foliage of single violets like California and Princess of Wales are sometimes slightly injured by the stronger dose of gas. A weaker dose (one-tenth of a gram potassium cyanide per cubic foot) should be used when they are to be treated.

Other plants.—Other plants on which the gas has been tried on a small scale indicate that it may probably have quite a wide range of usefulness.¹

Roses.—"Perle des jardins," "Mermet," and "Bride." The young growth on roses is particularly sensitive and has been more or less injured in all our experiments.

Carnations.—Scott, Garfield, Meteor, and McGowan will stand one-tenth of a gram of 98 per cent cyanide per cubic foot of space for 15 minutes without material injury. This will kill about 90 per cent of the plant-lice, but will not kill thrips. The use of the gas for carnations needs to be more carefully investigated before it is recommended. The same is true of chrysanthemums, on which it has been tried with only partial success, the young growth being very sensitive.

Grapes under glass.—The gas has been used with success in New Zealand² for mealy bugs (*Dactylopius adonidum* L.) at the rate of one-third of an ounce 98 per cent cyanide to 100 cubic feet. This is equivalent to nine-hundredths gram per cubic foot. The gas is liberated after dark and left in till next morning, when thorough ventilation is given. It largely escapes, however, during the night. The treatment is said not to injure the plants in the least.

Tomatoes.—Dr. Jabez Fisher, in "American Gardening" (Oct. 29, 1898), reports using the gas for "white fly" (*Aleyrodes* sp.) on tomatoes. The gas from one ounce of pure cyanide of potassium for each 1,000 cubic feet left in the house over night killed all the insects without injury to the plants. This method has not yet proved successful with us in any case, but it should nevertheless receive careful trial by other experimenters.

CUBIC CONTENTS OF THE HOUSE.³

In all cases where fumigation with this gas is to be followed it is necessary to first determine accurately the cubic contents of each house. The determination of the cubic contents of the house, while in itself a comparatively simple problem, has, in the eyes of many growers, difficulties which they are not willing to undertake. The cubic contents can be determined by a comparatively simple mathematical calculation, but perhaps the easiest way is by a method recently described by the writer in the Florists' Exchange [Vol. II, no. 5]. This method involves nothing more difficult than the mere counting of a number of squares, and from an examination of the accompanying illustration [fig. 5] the simplicity of the method will become apparent. Procure from a stationery store or art supply store some cross-section paper, such as represented in the figure. In this particular case squares of three sizes are shown, the largest being one-half inch, the next one-fourth inch, and the smallest one-sixteenth inch square. The one-fourth inch squares may represent feet. Now determine the dimensions of the house—that is, the length, width, height to ridge, and height on sides, and make a sketch as shown, each square or one-fourth inch representing 1 square foot. This particular house, it will be seen, is 18 feet (18 squares) wide, 12 feet to the ridge, 6½ feet high at the back, and 4½ feet high in front.

The ridge stands 5 feet from the back wall, as shown in the sketch. After the lines are drawn, simply count the squares inclosed, and the number of squares will be the number of square feet. The parts of squares, that is, where a line divides a square, can be easily determined by counting the smallest squares, or by the eye, and by adding these fractions of squares together the number of whole squares may be readily found. After the number of square feet is obtained it is only necessary

¹The gas has been used on the following plants at the rate of one-tenth gram of cyanide per cubic foot of space for twenty minutes without injury. Further experiment, however, is necessary before the treatment can be recommended for these: *Alocasia Macrorrhiza variegata*; *Anthurium crystallinum*; *Arceia lutescens*; *Aralia filicifolia*; *Adiantum cuneatum*; *Adiantum Ballii*; *Campylobotrys refulgens*; *Cissus discolor*; *Crotons* (in variety); *Cichorium intybus*; *Diffenbachia Lemmanii*; *Ficus elastica*; *Fuchsias* (in variety); *Jacaranda mimosaefolia*; *Marantas* (in variety); *Nymphaea candidissima*, and *odorata rosea*; *Pontederia crassipes*; *Pandanus veitchii*; *Phrynium variegatum*; *Phyllotænium Lindenii*; *Panaz Victoria*; *Stenanthium Lindenii*.

²Fourth Report, Dept. of Agr., New Zealand. 1896. Pp. 141-143.

³The method described is quoted from B. T. Galloway's Book on Violet Culture.

to multiply this by the length of the house in feet and the result will be the cubic contents. For example, supposing the house in question is 100 feet long, it contains $150\frac{1}{2}$ squares or square feet, and $150\frac{1}{2}$ multiplied by 100 equals 15,050 cubic feet. The whole operation requires less time than it takes to describe it and will apply, of course, to a house of any shape or size. It may be added that if the cross-section

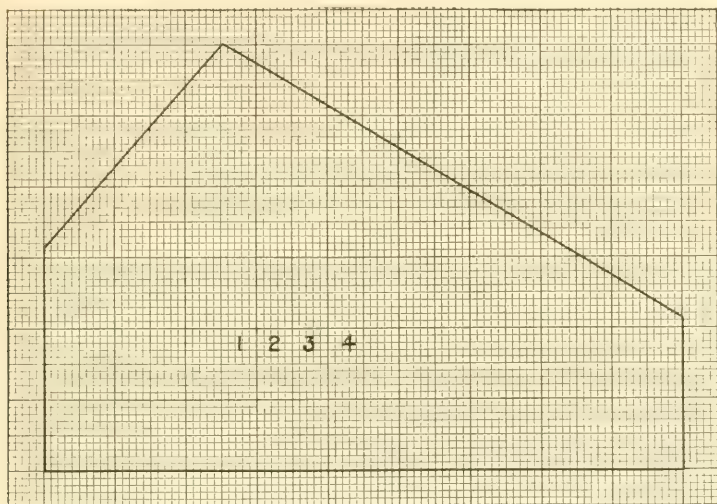


FIG. 5.—Diagram illustrating method of determining cubic contents of greenhouses (after Galloway).

paper can not be obtained readily the sections or squares can be laid off with a rule and lead pencil and practically the same results obtained. In any event, it is only necessary to get an accurate outline drawing of the section of the house, and by projecting this over squares as indicated the number of square feet in the section can be readily determined.

SELECTING A TIME TO FUMIGATE.

Care should be taken to select a night when the houses can be ventilated the required time without injury to the plants and when there is little or no wind.

PREPARATION OF THE HOUSE FOR FUMIGATION.

On account of the very poisonous nature of the gas, it is necessary to arrange a number of ventilators, the more the better, so that they can be easily opened from the outside. It would be very dangerous to enter the house while it contains the gas. All broken glass should be replaced and holes stopped up; a thoroughly wet piece of newspaper will close a crack effectually or take the place of a broken glass if necessary. It is best not to permit the gas to get into fire pits or engine rooms; these should be cut off from the space to be fumigated.

In case of a large range of houses opening into each other it is best to separate them into several sections, by tacking up building paper or oiled cloth, so that each section may be fumigated separately and at different times. The work may thus be done with greater ease and care, and with less danger to the plants. When all the larger cracks and openings have been stopped up, if the house is quite old or loose it is well to wet the roof on the outside just before fumigating. The water will fill the cracks between the glass and will assist in making the roof tight.

METHOD OF MAKING THE GAS.

The materials required are 98 per cent cyanide of potash, best secured in 5 or 10 pound cans at 35 to 40 cents a pound, and commercial sulphuric acid at 3 to 4 cents a pound.

For an ordinary house or frame, good vessels for liberating the gas are $1\frac{1}{2}$ or 2 gallon earthen jars of as small diameter as possible, so as to insure the immersion of the cyanide of potash when it is dropped into the acid. One jar should be used to about every 50 feet in length of such houses as described, in order that the gas may be quickly distributed when set free. When the jars are placed in position the next step is to arrange to lower the paper bags containing the desired amount of cyanide into the jars, from the outside. This is best done by passing a cord through a hook or screw-eye attached to the roof over each jar in such a manner that when the string or strings are loosened from the outside the bags of cyanide will be lowered into their respective jars, as shown in fig. 6. When the strings are ready, divide the amount of cyanide to be used into parts corresponding to the number of jars. Do each part up in a couple of thicknesses of ordinary newspaper and put in ordinary brown paper bags, and attach the bags to the strings, as shown in fig. 6. While the jars are empty test the arrangement to see if it works satisfactorily. After each bag



FIG. 6.—Violet house prepared for fumigation (from Woods & Dorsett).

is suspended in place, the other end of the string securely fastened where it can be reached from the outside, and the arrangement tested, move the suspended bags to one side, so they will be out of the way while putting the water and acid in the jars. When this is done, pour into each jar an amount of water about equal to the bulk of the potassium cyanide in the bag. Eight ounces of cyanide will require about half a pint of water. The sulphuric acid should then be poured in until steam rises from the water. This would require for a pint of water about a pint and a half of acid. It is not necessary, however, to measure the acid, as the evolution of steam indicates when the right amount has been poured in. Always put the water in first and then pour in the acid. As soon as this is done place the bags over their respective jars. In order to prevent injury to foliage in case it is very near the jars, it is a good plan to surround each jar by some protection. A section cut from a roll of building paper is effective. The paper naturally rolls into a tube and is very convenient for this purpose. The pieces may be laid together and tied when not in use,

so that they will keep their shape. When all is ready, go out quickly, close the door, and carefully loosen the strings, allowing the bags to settle into the acid. The gas will very soon be given off and fill every portion of the house. It is colorless and smells and tastes like peach pits. A little of it is harmless, but too much will cause death. A small quantity will leak out of the house; avoid positions where it can be smelled. The time of exposure should be reckoned from the lowering of the cyanide into the jars. When the proper time has elapsed, varying for different plants, as previously stated, quickly open the ventilators from the outside, so that the gas can escape as rapidly as possible. It will all be gone from a large house, such as described in this circular, in half or three-quarters of an hour, and the ventilators can then be closed if necessary. Next morning the material left in the jars should be emptied into a hole and buried. It is nothing but sulphate of potash, sulphuric acid, and water, having a little hydrocyanic-acid gas in solution. The latter will soon disappear, and the sulphuric acid will unite with lime in the soil, forming gypsum.

FUMIGATING BOXES.

For the purpose of experimenting and where only a few hundred plants are to be treated, a tight box may be made of 30 to 50 cubic feet capacity. The box should be as nearly air-tight as possible, with a removable cover and a small door at the bottom for introducing the cyanide of potash into the bowl containing water and sulphuric acid, as shown in fig. 4.

The wire trays as shown in the same illustration are used in fumigating cuttings of coleus or other plants. When desired the trays can be removed and pot plants set in the box and given such fumigation as desired. To prevent injury to the plants they should be so set that the foliage does not come within 18 inches of the bowl near the small door. When the plants are arranged the top is put on securely and a little water is poured into the bowl, and then sulphuric acid is added till steam is formed. The necessary amount of cyanide wrapped in a small piece of newspaper is then dropped into the bowl and the little door quickly closed. When the desired length of time has elapsed take off the cover and open the door and retire, so as not to breathe the gas. In a few minutes the gas will have sufficiently escaped so that the plants may be taken out and others treated in the same way. Injury (if there is any) to the plants may not show for two or three days, so in the case of experimenting, conclusions should not be hastily drawn. The box may be used in the daytime if the work is done in a cool place. For experimental purposes and treating plants on a small scale, a small greenhouse containing 1,000 cubic feet, or less, is better than a box, as the results obtained with it are more reliable, and there is less danger of injury to the foliage.

CONDENSED DIRECTIONS.

- (1) Carefully determine the cubic contents of the house and the amount of cyanide of potash to use.
- (2) Make the house as tight as possible.
- (3) Arrange so that the ventilators can be opened from the outside.
- (4) Place the jars and strings in position.
- (5) After dark attach the bags containing the cyanide to strings, as described, and find if they work correctly.
- (6) Hang the bags to one side and put water and acid into the jars; arrange protection and put the bags in place again.
- (7) When all is ready lower the bags into the jars by loosening the strings from outside.
- (8) After the proper exposure open the ventilators from outside, leaving them open from thirty to forty-five minutes before entering the house.
- (9) Next morning bury contents of the jars.

CAUTION.

It should be remembered that hydrocyanic-acid gas is one of the deadliest poisons known, fatal to human beings and plants as well as to insects.

Greenhouses which are within 50 to 75 feet of dwellings should not be fumigated unless the windows and doors of the latter on the side next to the greenhouse can be closed during the operation.

The bag containing the cyanide should not be permitted to drop into the jar until the operator has left the house.

It is essential that the exact proportion of cyanide be used at the rate designated for each cubic foot of space and that the exposure should not exceed the limit ascertained by experiments as appropriate to the plants to be fumigated. A greater strength of gas or a longer exposure than specified is apt to result in injury to the plants.

It is best to use this method at first experimentally on a small scale before attempting the fumigation of an entire greenhouse, and a preliminary test should always be made in case plants of a species or variety not previously fumigated are to be treated.

Concerning the possibility of hydrocyanic-acid gas forming a deposit upon any of the substances with which it might be brought in contact in its ordinary use as a fumigant, either in greenhouses or in buildings infested by indoor insects, Dr. H. W. Wiley, chemist of the Department of Agriculture, states that there is no possibility whatever of such a contingency, unless the gas comes in contact with some alkaline body, such as soda or potash, with which it would form a salt. The soluble cyanides are extremely poisonous, and if this gas were to act upon lye, or any similar alkaline body, a certain amount of cyanide would be produced. In a dry room, in the absence of alkaline bodies, there could not be any possible danger of a poisonous body being formed.

THE VIOLET SAWFLY.

(*Emphytus canadensis* Kby.)

RECENT INJURY.

October 19, 1897. Mr. Dorsett brought to this office specimens of the larvæ of this sawfly with the information that they were injuring violets in his greenhouses at Garrett Park, Md. He had experienced great trouble with this pest and stated that Mr. Joseph Markle, of Rhinebeck, N. Y., was similarly annoyed by its presence on greenhouse violets. Later Mr. W. G. Saltford, of Poughkeepsie, N. Y., sent specimens of the larvæ to this office, and Mr. B. T. Galloway, of this Department, also submitted for identification another lot of larvæ from Garrett Park, Md. From material received from Mr. Dorsett the adult was reared, and from the bred lot a number of observations on the development of the species were made and will be here recorded.

January 12, 1900, Dr. James Fletcher reported attack by the larvæ of this insect during the previous year in the extensive violet houses of Mr. J. H. Dunlop, of Toronto. He stated also that it was a common pest at Ottawa on pansies and some species of violet.

DESCRIPTION OF THE SPECIES.

The *female sawfly* may be recognized with the aid of the accompanying illustrations—figure 7, *a*, representing the insect with wings expanded and three times the natural size, figure 8, *c*, showing the same with wings folded and natural size, on a violet leaf—and Cresson's translation of Provancher's description (Tr. Am. Ent. Soc., Vol. VIII, p. 38):

“♀.—Length, 0.22 inch; black; head transverse, angular, as broad as the thorax, punctured, with a furrow on each side behind the ocelli; antennæ moderate; palpi, tegulæ, legs, with trochanters and tips of the coxæ, dull yellowish-white; posterior femora except base, tips of their tibiæ, with their tarsi, black or deep brown; abdomen entirely black, short and stout; wings hyaline, nervures brown, the costa and stigma deep brown.”

The flies reared at Washington differ slightly from the above description, as did those reared by Dr. Dyar, in having the fore and middle tarsi darker toward the apex. Some of the veins and stigma are very dark brown and others are black.

Measurement of the material at hand gives an average of 12.5^{mm} wing expanse and 6.5^{mm} total length of body.

THE EGG AND OVIPOSITION.

The individual fly which issued April 18 was placed in a jar with a potted violet plant, and was soon running about on the leaves with vibrating antennæ and active jaws and ligula, apparently feeding freely and making frequent attempts to insert her ovipositor in the leaves. This she was unable to accomplish with many of the older leaves, nearly all of the eggs found having been inserted in the tenderer leafage. Oviposition and the subsequent escape of the young larva from the place of deposit is not unlike that of the common pear slug, *Eriocampoides limacina* Retz., with the process reversed, the egg being inserted from the upper side of the leaf and the larva escaping on the under surface. The ovipositor is thrust through from above to the lower epidermis, which is left intact, the nidus thus formed with its contained egg appearing as a blister on the lower surface.

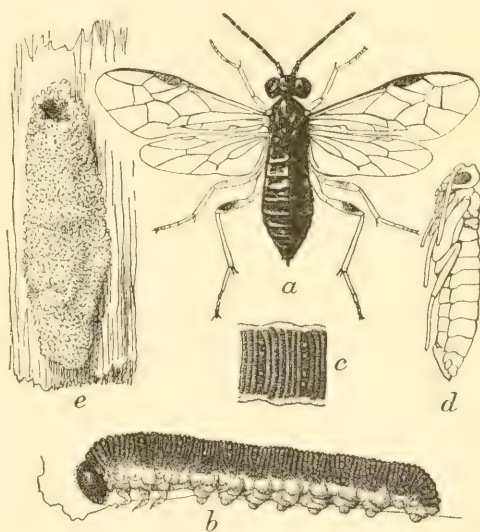


FIG. 7.—*Emphytus canadensis*—*a*, female sawfly; *b*, larva; *c*, abdominal segments of larva from above; *d*, pupa; *e*, cocoon—all except *c* four times enlarged (original).

The egg.—The egg is soft and delicate, and when dissected out appears to be rather variable in shape, but the normal outline seems to be elliptical oval, those deposited on the outer surface being inclined to reniform and narrowed at one end. It is somewhat flattened on its lower surface. Its length is nearly twice the width, the color limpid whitish, surface moderately polished, with no apparent sculpture. Eggs that were measured two or three days after deposition were about 0.7^{mm} in length and a little over half that in width; some, however, were much shorter in proportion to the width. The membrane

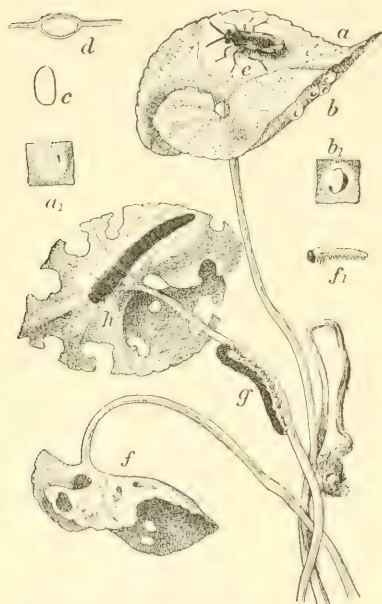


FIG. 8.—*Emphytus canadensis*—Violet leaves showing nature of attack and the following: *a*, egg cells on upper surface of leaf; *a*¹, an egg cell magnified; *b*, cells after escape of larva; *b*¹, one of same magnified; *c*, egg from above; *d*, egg *in situ* from side; *e*, female at rest on leaf; *f*, newly hatched larva on leaf; *f*¹, same enlarged; *g*, active stage of larva; *h*, full-grown larva feeding. *a*, *b*, *c*, *f*, *g*, *h*, natural size; *a*¹, *b*¹, *c*, *d*, *f*¹, more enlarged (original).

of the epidermis protecting the egg on the lower surface of the leaf, although thin, does not permit a good view of the egg within. There is little doubt, however, that the eggs of this species, like those of other sawflies of similar habits, increase in size soon after they are laid, by the absorption of nutriment through their membranous skins from the vegetable juices which surround them.

Eggs are laid singly, but it could not be ascertained whether only one or two are deposited normally on a leaf at one time, although many are often found on a single leaf. These may be deposited by different females or by the same individual on different visits.

In figure 8 the egg cells with the slits made by the female in oviposition are shown on the upper surface of the leaf at *a*, natural size, and much enlarged at *a*¹. The under surface of the cells on the lower surface of the leaf are shown natural size at *b*, and enlarged at *b*¹.

These illustrate the method of escape of the young larva from the egg. The egg is shown much enlarged in outline at *c* and in section *in situ* at *d*.

DESCRIPTIONS OF THE LARVA AND PUPA.

The loss of the material under observation through failure of the eggs to hatch prevented detailed descriptions of the various stages.

The newly-hatched larva.—The larva when first hatched presents the appearance shown in figure 8. At *f* is shown at the right a larva

natural size crawling on a leaf, and, at the left, one in the curled-up position which it assumes when disturbed. At f^1 it is shown, lateral view, enlarged; the color is light slaty, and the head, it will be seen, is proportionately larger and the legs longer than in its more mature stage; its length is about 2.5^{mm} . At g of the same figure, the penultimate stage, which appears to be the most active, is shown from the side resting quietly on a leaf stalk.

The full-grown larva.—A mature larva is illustrated at h of figure 8, feeding upon the under surface of an injured violet leaf. It is here represented in its largest state. After ceasing to feed it begins to contract, and assumes more of the appearance of figure 7, b , which represents the larva in its most characteristic form. The general color of the larva, as it approaches maturity, is dark dull olive or slate above with a bluish tinge. It is rather conspicuously marked with minute white tubercular spots, arranged in transverse rows of four dorsal and two lateral on each side, as shown in the illustrations, but these disappear in the contracted final stage and can hardly be detected in preserved specimens. The ventral surface is pale-gray, also with a bluish tinge.

The length of the mature larva as it lies extended on a leaf just before the last molt previous to the final prepupal stage is about 15^{mm} . When fully extended it measures 18^{mm} , and in its contracted state just prior to pupation it is only about 8.5^{mm} in length.

A larva that came under observation May 6 will well illustrate the changes of color just prior to and after molting. Immediately before this molt, which occurred at 11.15 a. m., the general color of the dorsal surface had become very dark, nearly black; a few minutes after molting it was very light, nearly uniform leaden gray, the ventral surface but slightly lighter, the head being now light pearl gray, with the black eyes showing prominently. When next seen, about five hours later, the general color had turned to glaucous blue. Next morning, when this larva was again examined, the color had not changed appreciably, except that it was a little darker and duller. The color undergoes but little change from this time till the contracted stage is assumed.

Dr. Dyar's technical description of the mature larva is appended:

Head rounded, normal, dull black, slightly slaty; eye and mouth black, the sutures around clypeus pale; some short pale hairs; width, 1.4^{mm} . Body of nearly equal width, slightly largest at anterior end; thoracic feet small, abdominal ones well developed, present on joints 6 to 13 (22 feet). Segments 6-annulate, rather sharply so, and about as distinct as the segmental incisures. Color slaty black dorsally, not shining, smooth, the dorsal vessel showing darker; below the spiracles olive gray. Thoracic feet pale. On each segment, on second annulet, a transverse row of minute white points, with a second one on first annulet stigmatically; a few less conspicuous ones on subventral ridge.

Final stage.—Head blackish above, pale below; eye in a black spot; mouth brown; antennæ and palpi pointed, minutely brown-ringed; width, 1.4^{mm} . Body entirely dark olive-gray, rather bluish, slaty, the segments neatly 6-annulate, not shining, evenly minutely granular. Feet transparent, spiracles in paler areas. No white points or tubercles.

The pupa.—The pupa is sufficiently shown at figure 7, *d*. It measures about 7.5^{mm} in length and is nearly white in color, the eyes turning darker as it approaches the time for final transformation.

The change to pupa in the confinement of our rearing jars took place in the pith of sunflower stems placed there for the purpose. A cocoon is shown at figure 7, *e*.

DISTRIBUTION.

Little can at present be said of the distribution of this species. Like the majority of sawflies, it is most abundant in the North, but has undoubtedly been disseminated by commerce in shipments of violets and pansies from one place to another. Its occurrence has not been noted out-of-doors in the vicinity of the District of Columbia to the writer's knowledge, and it would therefore seem probable that it is a comparatively recent introduction, if we may use the term in speaking of a native species being established in new localities. The known distribution embraces Plattsburg, Rhinebeck, and Poughkeepsie, N. Y.; Garrett Park, Md., Toronto and Ottawa, Canada.

It is not a little singular that a northern species of insect as this seems certainly to be should become acclimatized in greenhouses as far south as the District, since it is a well-established fact that a very large proportion of the insects that lead an indoor life are of tropical origin.

HISTORY OF THE SPECIES.

This species was first described in the year 1878 by the Abbé L. Provancher as *Enophytus pallipes*, a name preoccupied by Spinola for a European species of this genus. Kirby's description of *E. canadensis* appeared in 1882 (List Hymen. Brit. Mus., Vol. I, p. 204). There are several accounts bearing on the biology of this species. One is by Dr. H. G. Dyar, of the U. S. National Museum, published in 1894 in the Canadian Entomologist, in which he describes the larva in the last two stages and gives some brief notes on its habits and occurrence on cultivated pansies at Plattsburg, N. Y. In the Florists' Exchange for August 7, 1897, Mr. B. T. Galloway published a short article on this insect under the title of "Injury to Violet plants," the species being identified as "an undetermined sawfly." Brief mention is made of the larva and its manner of work, the article being devoted mainly to methods of control. The nature of injury by the larva is illustrated. This article was republished in American Gardening for August 21 of the same year. In Fauna Ottawaensis Hymenoptera Phytophagica, an article by Mr. W. H. Harrington, published in volume VII, Ottawa Naturalist, and consisting of a list of the Phytophagic Hymenoptera taken in the neighborhood of Ottawa, Canada, the following appears concerning this species: "Eight females. May 8, June 9. Violets and pansies."

In his annual report as Dominion entomologist of Canada for 1898 (p. 169), Dr. Fletcher briefly mentions considerable injury that was done in beds of violets at Toronto, Ontario, reported to him by Mr. J. Dunlop, a florist of that city. He states that complaints of this false caterpillar have occasionally been noticed in the past to foliage of pansies (*Viola tricolor*, varieties), but that no great injury had previously been recorded.

Brief notice of Mr. Pratt's rearing of this species in 1899 from violets received from Rhinebeck, N. Y., was recorded in the proceedings of the Entomological Society of Washington (Vol. IV, p. 302).

During the fall of 1899 Mr. Galloway published in his book entitled "Commercial Violet Culture" a short account of this insect, without, however, mentioning the species scientifically.

The same year Dr. Fletcher again mentioned this species somewhat briefly in connection with injury to pansies and violets at Toronto, Canada (Transactions Royal Society of Canada, Vol. V, second series, 1899-1900, p. 228).

BIBLIOGRAPHICAL LIST.

The bibliography of this species is moderately extensive. A list of articles arranged in order of publication is appended for convenience of reference:

- L. PROVANCHER, *Naturaliste Canadien*, vol. X, p. 66, 1878.
 E. T. CRESSON, *Trans. Amer. Entom. Soc.*, vol. VIII, p. 38, 1880.
 W. F. KIRBY, *List Hymen. Brit. Mus.*, vol. L, p. 204, n. 49, 1882.
 L. PROVANCHER, *Faun. Entom. Canada. Hymen.*, p. 192, 1883.
 W. H. HARRINGTON, *Ottawa Naturalist*, vol. VII, p. 122, Nov., 1893.
 H. G. DYAR, *Canadian Entomologist*, vol. XXVI, p. 185-6, 1894.
 B. T. GALLOWAY, *Florists' Exchange*, vol. IX, p. 720, Aug. 7, 1897; *Am. Gardening*, vol. XVIII, p. 585, Aug. 21, 1897.
 JAMES FLETCHER, *Rept. Entom. & Bot. Expt. Farms Dom. Canada for 1898*, p. 169, 1899.
 [F. C. PRATT]. *Proc. Entom. Soc. Wash.*, vol. IV, p. 302, 1899.
 B. T. GALLOWAY, *Commercial Violet Culture*, New York, 1899.
 JAMES FLETCHER, *Trans. Roy. Soc. Canada*, vol. V, 2nd ser., 1899-'00, p. 228.

MANNER OF WORK—HABITS OF THE LARVÆ.

The larvæ, while very young, feed on all parts of a leaf by cutting out little holes from the lower surface, and later, when more mature, eating along the edge of the leaf. Occasionally, at least, they nibble the flower stalk and destroy the flower, as shown in the illustration (fig. 8). An idea of their injuriousness may be had when it is said that the potted plant on which the larvæ were first kept began to wither and die during the third week of April, necessitating the removal of as many large larvæ as could be found to prevent the entire destruction of the plant. The second plant was injured in like manner, and the next two or three colonies completely stripped the first

plant of leaves. A third plant was also defoliated. In a few instances larvæ attacked the stems, in one case eating them off nearly to the roots.

Injury by the larger larvæ is much worse, the younger ones appearing to confine attack to cutting small holes here and there in the leaf.

The punctures made by the females in oviposition and the holes made by the larvæ in escaping from the nidus in the leaf also cause injury, particularly when the eggs are deposited in a bunch, as shown in the illustration (fig. 8, *a*, *b*). The tip of the leaf withered and nearly died as a result of this attack.

The younger larvæ have the habit of resting during the daytime, usually in a curved position like the letter J. When disturbed even slightly, they promptly curl up spirally, after the manner of many Tenthredinids, and drop from the plants to the earth below. All of the youngest larvæ that have come under observation rest thus on the lower surface of the leaves, and are never curled spirally when upon the leaf. The more mature larvæ may be found during the daytime extended lengthwise on the leaves and more particularly along the stems near the ground, but sometimes in other positions, with their heads usually pointed upward but often downward. In this position they are afforded sufficient concealment on fresh plants to readily escape notice. On such plants, except when occurring in great numbers, they are eminently successful in eluding observation at nearly any time. For example, only one or two of the nearly grown larvæ in a lot of upward of a dozen on a small plant were to be seen at one time, the others being securely hidden from view.

Of the first two broods reared—using the word not in the same sense as generation, but as the progeny of one female—it was quite noticeable that the larvæ did not in any case desert the plant on which they had hatched until they were mature or very nearly so.

Injury is most apparent late in May and early in June, and almost entirely to plants grown under glass, being particularly noticeable, upon plants growing in shaded locations, such as are to be found in greenhouses, under gutters, where the plants grow ranker. In some cases injury appears to be confined to such locations. In the greenhouse, according to Mr. Galloway, "seldom more than two of the worms are found at one time on the same plant. Two, however, are enough, as they will riddle a half-grown plant in a week."

Mr. Dorsett's experience with this species goes to show that it is quite persistent in the greenhouse, and difficult to dislodge after it has obtained a foothold, in this respect ranking with several other species, such as the "red spider" and the aphides, which are not, like the sawfly, limited to any one genus of host plants. In spite of frequent and systematic fumigation and careful watchfulness in his greenhouse, this species continues to be seen, although in small num-

bers, at intervals every year. This is the more remarkable in that the species has practically become an indoor one so far as we know, and the individuals found from time to time are therefore evidently survivors of the original lot first introduced in a previous year.

The length of life of the mature sawfly is only a matter of three or four days. It was noticed of the adults that were transferred to new quarters for oviposition, when first issued, that they died in this time. One that was found just casting off its last pupal skin June 10 was isolated on a potted violet on the 11th, was observed living as late as noon of June 13, and was found dead and dry on the morning of the 15th. It had evidently lived an active life of only three or four days.

PARTHENOGENESIS.

The material received in October, 1897, was taken in charge by Mr. Pratt and confined with potted violets, surrounded by a glass cylinder, resting upon a base containing sand, which was kept moderately moist, as the plants did not require a very great degree of moisture. Upon this sand there was placed a stem of sunflower, containing pith, and in this the larvæ constructed their cocoons. The first adult was observed March 17, 1898, its appearance being nearly coincident with the blooming of its host plant; a second and third appeared about April 7, a fourth April 18, and a fifth was found May 2. All of the imagoes reared were females.

April 7 the writer noticed young sawfly larvæ feeding on the leaves of the plants used in these observations. This was prior to the appearance of any except the first issuing adult, and is proof conclusive of parthenogenesis in this species—a not unusual occurrence in Tenthredinidæ, but more commonly met with in certain other families of Hymenoptera, and particularly well known in Cynipidæ.¹

April 16 at least two new broods of the larvæ were observed, the progeny of the females that were found dead April 9, and yet another brood was obtained from the female which issued late in April, furnishing still further evidence of parthenogenesis.

All of the flies reared in May and June were females. A portion were placed with two pots of violets, but not carefully watched, as it was not deemed necessary to do so with this generation, it being the intention merely to note from the time of first egg-laying to the issuance of the first fly of the next generation, and then to follow this last closely, to obtain all stages of the midsummer generation. Only a few larvæ hatched, and it was then found that the plants were dying from

¹Parthenogenesis in the Tenthredinid genus *Emphytus* has been recognized by the distinguished zoologist, C. Th. E. von Siebold. In *Entomologische Nachrichten* (Vol. X, p. 95), published in 1884, he records the fact that eggs laid by virgin females produced males in the European species *Emphytus cinctus* L. and *E. viennensis* Schr.

“red spider” attack. It is almost certain that this same red spider had killed the sawfly eggs or at least prevented their development.

DEVELOPMENT.

The first of the larval offspring of the female found March 17 attained mature growth and deserted the plant on which it had fed May 3. In the absence of more accurate information we may assume that this female issued about March 14, and that eggs were deposited during the next three days. It may be assumed also that the egg stage was at this season about eighteen days, which would leave an active larval period of about four and a half weeks.

From eggs that were deposited by a fly which was confined alone with a violet plant April 19, the first larva hatched May 1, giving as the duration of the egg state for this period, which was colder than normal, twelve days.

From May 4 until about the 10th or later the other larvæ of this brood, about a dozen in number, deserted the plant and crawled about on the glass cylinder confining them.

May 25 the first fly of this brood was found to have issued, having passed the entire cycle from egg to imago in about ten weeks.

The first larval molts of the first spring generation were not observed. A number of mature larvæ were isolated and observations made from the time of the penultimate molt to the issuance of the adult.

No. 1 molted April 21 and afterwards, and transformed to pupa May 25.

No. 2 molted April 22, also afterwards, and transformed to pupa May 26.

Nos. 3 and 4 molted May 10, and had assumed the contracted form by May 21. May 25 both transformed to pupa, and to imago May 31.

No. 5 molted May 6, began May 9 to bore into the pith of a stem supplied for the purpose of pupation, and in the course of an hour had obtained entrance and closed the aperture with the comminuted bits of pith produced by its boring. May 14 a portion of pith was removed that further transformation might be observed. Pupation ensued May 25 and the adult appeared June 1. The last fly observed issued June 11.

These periods, if so we may term them for present convenience, are of course variable according to atmospheric conditions—heat or cold, humidity or dryness—and are probably also subject to individual variation in the larval stage. Approximately, we may say that the penultimate larval molt in the first spring brood takes place about five weeks from the time of pupation, the final larval molt occurring about eighteen or twenty days later than this. The duration of the final contracted larval stage could not definitely be determined, as it is gradual and hence it is difficult, if not impossible, to determine where

the penultimate larval stage ends and the final stage begins. Of this, however, we are certain, that there is an inactive period, or at least what we may consider such, although neither larva nor pupa is truly quiescent, of at least two weeks during which the larva remains in its pupal cell.

The entire cycle from the date of laying of the eggs to the issuance of the first adult was between eight and ten weeks.

From the above data the approximate life cycle for the first spring generation may be deduced as follows:

	Days.
Egg period, from laying to hatching.....	12-18
Active, feeding stage of larva.....	24-31
Inactive or nonfeeding larval stage.....	14
Pupal stage.....	6-7
Entire life cycle.....	56-70

NATURAL ENEMIES.

As only a single lot of this species was used in rearing, no parasites were developed. In one instance, however, an adult fly, not yet mature, was found to have succumbed to mites and it has already been stated that eggs were destroyed by red spiders. No larvæ died as far as noticed, although the first generation was exposed to a temperature which was below freezing out-of-doors and not much higher in the rearing jar, which stood near an open window in an unheated room.

REMEDIES.

The violet sawfly is amenable to the same remedies that have been found most useful against the greenhouse leaf-tyer in greenhouses. Hand-picking of the larvæ has been employed with some success by Mr. Dorsett and others, but is too slow to be entirely satisfactory and the larvæ are difficult to discover. Extract of tobacco diluted at the rate of 1 part extract to 30 parts of water was also effective when applied as a spray, but florists are opposed to the use of tobacco on violets owing to its tendency to weaken the plants and to bring on the condition known as "spot." The main reliance at present is in the hydrocyanic-acid-gas treatment, as described in the foregoing article on the greenhouse leaf-tyer.

THE TWO-SPOTTED RED SPIDER.

(*Tetranychus bimaculatus* Harvey.)

Perhaps the most troublesome of greenhouse pests, everything considered, are minute reddish spider-like creatures known popularly as "red spiders." They often do very considerable damage in flower and vegetable gardens, but in greenhouses they attain their greatest destructiveness, and are particularly injurious to violets and roses, as well as to a great variety of other plants.

Until within the year 1900 the common red spider most often occurring in greenhouses was technically designated as *Tetranychus telarius* Linn., a name which has been rather indiscriminately applied to all species of red spiders, both in America and abroad.

Red spiders are not true insects, in fact not even spiders, but are, more properly speaking, spinning mites. Since, however, they are almost universally known as red spiders, this term is retained for present purposes.

As the word "mite" indicates, these insects are extremely minute, and when they occur in ordinary numbers are not apt to be noticed unless leaves are carefully scrutinized. Attention, however, is certain to be drawn to them when they become excessively numerous, as frequently happens in neglected greenhouses or out of doors during droughts in summer.

Red spiders spin threads, but do not, like true spiders, utilize them for climbing or descending from a height. The threads spun are extremely fine and scarcely perceptible to the unaided eye, but a web of threads is frequently so dense as to form a tissue plainly visible at a little distance. Webs are usually constructed

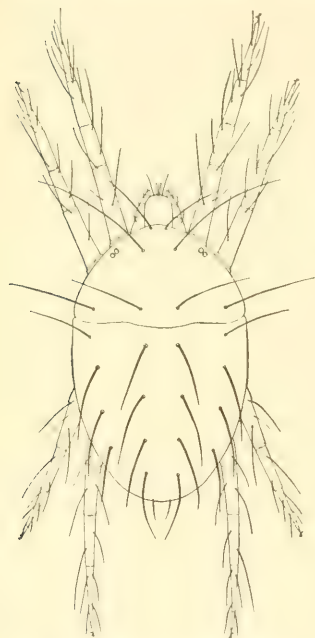


FIG. 9.—*Tetranychus bimaculatus*: adult—enlarged (from Banks).



FIG. 10.—*Tetranychus bimaculatus*: palpus—enlarged (from Banks).



FIG. 11.—*Tetranychus bimaculatus*: claws—enlarged (from Banks).

upon the lower sides of leaves, and attached here and there to projecting hairs, veins, or the edges of the leaves. Within the webs thus formed the mites feed in their different stages, and the eggs are laid from which the young develop.

The general appearance of the red spider under consideration, which is now known as *Tetranychus bimaculatus* Harv. as it looked under a microscope, is well shown in figure 9. At figure 10 a greatly enlarged palpus of the same species is illustrated, and figure 11 shows the claws similarly enlarged.

The length of full-grown individuals, including the palpus, is from 0.4 to 0.6 mm and the width 0.25 to 0.30 mm, the thickness being 0.17

to 0.20^{mm}. The form is broadly oval, the width greatest in the anterior third of the body, back of the eyes, where the sides are somewhat distended. The general color of the adults is reddish, usually more or less tinged with yellowish or orange, and most specimens have a dark spot on each side, due to the food contents of the body, from which the scientific name *bimaculatus* (two-spotted) has been derived.

Careful study of different individuals as they occur on garden vegetables and horticultural and other plants grown out of doors with those taken in greenhouses shows no appreciable differences. According to Mr. Banks, however, specimens taken in Florida on *Datura* and at Washington, D. C., on violets are red, while those from Orono, Me., and those from the District of Columbia on squash and peaches, and those on rose from Idaho, are greenish with more or less dark markings.

The eggs are extremely minute, spherical, of variable diameter, glassy, and are scattered and loosely attached about the webs.

The young are of somewhat similar appearance to the adults, but differ in having only three pairs of legs.

DISTRIBUTION.

If, as seems probable, *Tetranychus cucumeris* or some other species described by Boisduval (Entom. Horticole) is identical with the present species of red spider, it is quite likely that it is of foreign origin and introduced into the United States, which is true of a very large proportion of greenhouse and other indoor insects.

The two-spotted red spider is well distributed through the eastern United States, and has been identified as occurring in localities as far west as Idaho. A list of localities from which the species has been reported includes Orono, Me.; Ithaca and New York City, N. Y.; Westgrove, Pa.; Washington, D. C.; Tremont, Pekin, and Bloomington, Ill.; Punta Gorda, Key Largo, Galloway, and Eustis, Fla.; Charleston, S. C.; Auburn, Ala.; and Weiser, Idaho.

RECENT INJURIES.

During the past two years we have received complaints of this species from various sources, as follows:

June 9, 1899, from Mr. H. M. Simons, who reported its occurrence on snap beans grown at Charleston, S. C. The species was stated to have literally overrun and totally destroyed the beans where discovered. It had not been seen in previous years, and it was noticed that the season had been very dry.

July 6 the occurrence of this red spider was reported by Mr. F. S. Earle on cowpea and beans at Auburn, Ala.

May 8, 1900, it was concerned in injury to raspberry at Bloomington, Ill., and reported to this office by Mr. J. L. Lampe, jr.

August 2, 1900, its occurrence on *Aprios tuberosa* was reported by the late Thomas A. Williams, of this Department.

Violets and carnations were seriously injured during the last two years in the District of Columbia, and we received in a letter dated March 19, 1901, information concerning general destructiveness by this species to strawberry in the vicinity to Galloway, Polk County, Fla. Our correspondent, Mr. E. G. Gardner, stated that the mites were always found on the underside of the leaves.

IDENTITY OF THE SPECIES; LITERATURE.

The subject of the specific identifications of the different species of red spiders which occur in this country, of which there are 11 distinct forms described, together with the characteristics which distinguish them, and other information of more or less technical import, has been already made public in a paper entitled "The Red Spiders of the United States," by Mr. Nathan Banks, published on pages 65-77 of Technical Series No. 8 of this Division.

Tetranychus bimaculatus was first described by the late Prof. F. L. Harvey in 1893 (Annual Report Maine State College Agr. Exp. Station, Part IV, pp. 133-144, pl. 3). This account includes valuable notes on the insect's habits and injuries, a tabulated list of host plants, extracts from correspondence, and a consideration of remedies, besides technical descriptions of the different stages of the species.

In Galloway's Commercial Violet Culture, already quoted, considerable space is devoted to a consideration of this species, mentioned as "redspider" (pp. 190-198), particular attention being given to remedial treatment based upon years of experience with it as it occurs on violets grown under glass.

The above-mentioned publications have been freely used in the preparation of the present article.

The species has been treated from the standpoint of an enemy of sugar beets, with brief mention of its occurrence on hemp near Tremont and Pekin, Ill., in 1899 and 1900, on pages 406 and 407 of Bulletin No. 60 of the University of Illinois Agricultural Experiment Station, by Messrs. Forbes and Hart.

FOOD PLANTS AND NATURE OF INJURY.

The two-spotted red spider is inclined to be omnivorous, attacking a wide range of both glabrous and hirsute plants belonging to several families. It is present in greenhouses throughout the year, and appears to be able at all times to be destructive if permitted to propagate. Few plants are, in fact, free from the attack of this red spider, and it is present in most greenhouses. When only a few mites are present, the plants seldom show any external evidences of injury, but as they

increase in number the leaves gradually turn paler and yellowish in color and become stunted, and soon the whole plant succumbs unless the proper remedies are applied. Cuttings or young rooted plants are particularly subject to serious injury, and this is especially true in the spring. At this time the mites multiply rapidly, and unless plants are carefully watched they are apt to become so badly infested that it is only with extreme difficulty that they can be restored to their normal growing condition.

The mites injure the plants by suction, and when they occur in numbers, which they almost assuredly will do when plants are neglected, the vitality of the plants is slowly but surely reduced by the loss of their juices, and in time all of their functions are more or less deranged.

In cases of severe attack, millions of red spiders can be found upon the foliage of plants, and the webs, which are rarely observable at ordinary times, sometimes stretch from plant to plant, and the mites may be seen passing rapidly over them and congregating in swarms.

The following list of food plants has been compiled from Professor Harvey's article previously mentioned (l. c., p. 142): Clematis, mignonne, pink, Indian mallow (*Abutilon* spp.), Pelargonium, Canary bird (*Tropæolum peregrinum*), beans, rose, apricot, Cuphea, Godelia, Fuchsia, Passiflora, cucumber, muskmelon, Manettia, Bouvardia, feverfew, Mimulus, slipper flower (*Calecolaria* spp.), Thunbergia, verbena, sage, heliotrope, cypress-vine, moon-flower, morning glory, tomato, pepino (*Solanum muricatum*), eggplant, pepper, wedding bell (*Brugmansia arborea*), castor oil plant, hop, calla, Boston smilax, and Easter lily.

Violets and roses are particularly troubled by this species of red spider, more especially, as might readily be inferred from what has already been said, when these plants are grown under glass. Peaches have been injured by the curling of their leaves; squash, corn, cowpea, raspberry, *Apios tuberosa*, strawberry, beets, hemp, and watermelon have also been reported to be attacked.

REMEDIES.

Red spiders are resistant to fumigation either with tobacco or hydrocyanic-acid gas, and only a portion of these creatures are usually killed by the ordinary use of the gas in greenhouses. They are stupefied for a time, but eventually recover. They are, however, extremely sensitive to sulphur, applied either dry or as a wash or in connection with other poisons, and to soap.

Flowers of sulphur, mixed with water at the rate of an ounce to a gallon and sprayed over infested plants, is of great value in the eradication of this pest; or the sulphur may be combined with a strong soapsuds. For the application of this spray a force pump with spraying nozzle is of course a necessity.

Kerosene emulsion and whale-oil and other soap solutions are also valuable, and the addition of the sulphur increases their effectiveness; but these washes are too strong for some plants and are apt to injure them.

For the particular red spider in question, as it occurs in greenhouses, particularly on plants that are liable to injury by the use of sulphur, such as violets, no other remedy is used by florists generally than frequent syringing or spraying with water or with a solution of neutral soap. Both have been extensively used by Mr. Galloway in growing violets, from whose experience the following instructions have been gathered:

Neutral soaps, such as castile soaps, are particularly valuable for use upon cuttings affected with red spider, and the best results have been obtained in using such at the rate of a 5-cent cake to 6 or 7 gallons of water. The soap is shaved with a small plane, dissolved in about a gallon of hot water, and then sufficient cold water is added to make the quantity desired. Five gallons are sufficient for the treatment of three or four cuttings of violets, and other plants are in proportion. It is customary to allow the soap to remain on the plants two or three hours, and then thoroughly syringe with clear water, repeating this treatment two or three times until the spiders and their eggs have been destroyed. Used in this way, the soap has little if any deleterious effect upon most greenhouse plants.

It is unsafe to use strong soaps, such as potash, whale-oil, or fish-oil soaps, as they are apt to injure delicate plants and are of no more value as insecticides than those of a neutral nature.

Tobacco water is of some use for the same purpose, but can not be recommended for violets owing to the tendency which tobacco has to weaken the foliage and induce "spot."

Spraying with water is usually practiced from two to three times a week during the growing season, and by a little practice and experiment with a fine spray nozzle or tip the operator will soon be able to ascertain the proper degree of force to use. A pressure of about 25 pounds has proved most effective against this red spider. Care should be exercised to wash off the spiders and at the same time not to drench the beds. When it is necessary to spray during the winter time work should be done on a bright day in order that the plants may dry off in a few hours.

Spraying apparatus.—For several years the want has been felt by florists of a spraying apparatus that would be perfectly satisfactory for use in greenhouses, and that could be purchased at a moderate price. Such a sprayer has been devised by Mr. Galloway, and the illustration here presented (fig. 12) shows its general appearance. It will be seen that it is an ordinary hand syringe fitted with a Vermorel nozzle and provided with a separate intake attachment.

To change the syringe to a sprayer a cap (fig. 13, *c*) with a larger opening is put on in place of the usual one, and into it is screwed the Vermorel nozzle. The nozzle proper (fig. 13, *n*) necessarily has a very small orifice, and to fill the syringe through this would require too much time; hence a larger opening is made (fig. 13, *o*), and into this a ball valve is fitted (fig. 13, *b*). This latter is so arranged that when the handle of the syringe is drawn up the liquid is drawn in through the opening, and when forced down the ball valve closes the intake and the liquid issues from the nozzle in the form of a mist-like spray.



FIG. 12.—Hand sprayer, complete (from Galloway).

This syringe, with its attachments, will be found valuable also for whitewashing benches, shading glass, and other purposes. The syringe under consideration was devised for the application of fungicides, but it may be used for insecticides also and for the application of water to plants; but for the syringing of plants with water, where this is

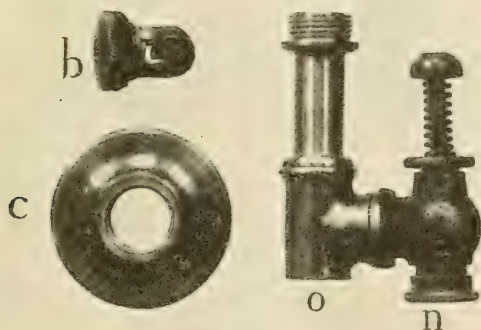


FIG. 13.—Parts of hand sprayer: *c*, cap; *n*, nozzle; *o*, opening closed by ball valve; *b*, ball valve (from Galloway).

practiced on a large scale, still another apparatus has been devised in the shape of a tip and nozzle of the form illustrated in figure 14. The nozzle consists of a casting turned to the desired length and flattened at the end, as shown. Through the flattened end a narrow slit is made, and it is important that the slit or opening be absolutely true

throughout, so that the water, when it issues, will be broken up into streams. It will sometimes be found necessary to file the tips as they come from the factory to produce the desired results.

The spray tip proper is attached to a brass fitting, which in turn screws onto the end of a three-quarter-inch hose. The apparatus is very effective for spraying roses, as it readily serves to keep the leaves in a thoroughly healthy condition, and at the same time wets the beds but little. It is also very useful for violets, as with a pressure of 35 to 40 pounds the leaves of the plant can be readily turned over and thoroughly washed without soaking the crowns and the bed. In spraying some plants, particularly violets, it has been found advantageous to use a lance 18 inches long, made of a piece of one-half-inch brass pipe. This increases the reach, and enables the operator to place the water to better advantage on plants which under ordinary



FIG. 14.—Tip and greenhouse nozzle, complete (from Galloway).

conditions would be beyond arm's length. The apparatus can be made for 50 cents, and will be found a useful instrument wherever there is sufficient water pressure to insure a proper amount of force. (Circ. 17, Division of Vegetable Physiology and Pathology.)

THE BLACK OR BROWN APHIS OF VIOLETS.

(*Rhopalosiphum violae* Perg.)

Until within five or six years from the present time one of the most troublesome insects upon greenhouse violets in the vicinity of the District of Columbia, as well as elsewhere, was a plant-louse known to florists as the "green fly" or "green aphis." Some time in the spring of



VIOLETS SHOWING INJURY BY PLANT-LICE.

1893 (or '4) Messrs. Galloway and Dorsett, at that time jointly concerned in the propagation of violets at Garrett Park, Md., noticed for the first time a darker species of plant-louse in their greenhouses, which in time practically displaced the other form and has become the most injurious violet pest of this vicinity and in other localities where it has been introduced. The matter was not immediately brought to the attention of any specialist in the Aphididae and the species was not identified until recently, even generically. What is with little doubt the same insect is now known to be widely distributed in our violet-growing regions, being generally recognized by the trade under the rather inappropriate name of "black aphid" or "black fly," by which cognomens it has received mention in recent years in various floral journals. Regarding its rank as a pest, Mr. George Saltford, a prominent violet grower of Rhinebeck, N. Y., says: "It is the greatest scourge of the violet grower to-day." (The Florists' Exchange for December 10, 1898.)

NATURE OF INJURY.

These plant-lice are to be found in greatest numbers at the crown of the violet plant, in the petioles and on the under side of the leaves, and they accomplish considerable injury by entering the young opening buds and inserting their haustella, or sucking tubes, through the overlapping petals. When the petals unfold they are seen to be distorted and bleached where they have been injured, these spots showing greenish-white, and in some cases almost pure white. The flowers also are dwarfed and distorted, the stems are nearly always shorter than is normal, and the flowers altogether present a weak, sickly, and unsightly appearance when contrasted with healthy blooms. Injury is apt to be very disastrous unless the aphides are destroyed in some manner. In the accompanying illustration (Plate II) normal violets are shown below, and a small bunch of flowers injured by this aphid are illustrated above.

This species of aphid has not been under continued observation, and hence we have no very full notes regarding its development. Winged forms were noticed in March, April, and May, and again during the first two weeks of November.

DESCRIPTIVE.

As the species was apparently undescribed, a description was drawn up by Mr. Th. Pergande and published in the Canadian Entomologist of February, 1900 (Vol. XXXII, pp. 29, 30). The grower of violets will readily distinguish this from the green aphides which affect his plants, with the aid of the accompanying illustration (fig. 15). The winged female, shown at *a*, is of attractive appearance. She has a dark cherry or purplish brown body, clear wings with the veins strongly and con-

spicuously clouded with dull black, as figured. The tail is short and inconspicuous; the nectaries are clavate, reaching to the tip of the abdomen. The species is somewhat remarkable on account of the inconstancy of the wing venation. Certain of the terminal veins are often wanting, as illustrated at *b*. The apterous or wingless female, shown at *c*, and the last stage of the nymph, (*d*), are of similar general color to the winged form, but usually paler.

The length of the body and head together is about $\frac{1}{4}\frac{1}{2}$ of an inch (nearly 2^{mm}) and the wing expanse about $\frac{1}{4}$ of an inch (5–6^{mm}).

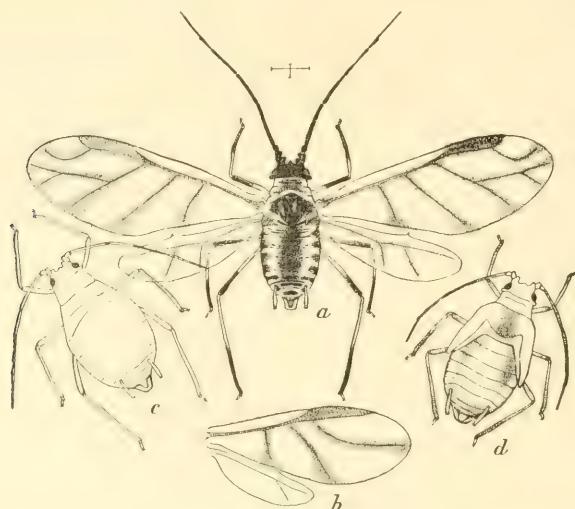


FIG. 15.—*Rhopalosiphum violae*: *a*, winged female; *b*, wing of same, showing aberrant venation; *c*, wingless (agamic) female; *d*, nymph—all much enlarged (original).

DISTRIBUTION.

This plant-louse is of doubtful nativity. The fact that it appears to confine its attack to plants grown indoors would indicate a tropical and therefore foreign origin; but as the species has been described from this country, and is not known elsewhere, it will have to be considered native until we learn to the contrary. The present distribution includes the following localities, the list being necessarily small on account of the newness of this insect as a pest: Toronto, Canada; Poughkeepsie, Rochester, and Cornwall-on-Hudson, N. Y.; Newton Center, Mass.; Providence, R. I.; Garrett Park, Waverly, Brooklyn, and elsewhere in Maryland; District of Columbia; Gordonsville, Va.

DIVISIONAL RECORDS OF INJURY.

In August, 1898, Mr. Dorsett visited Mr. Theodore Diedrich at Anacostia, D. C., and ascertained from that gentleman that this species had done immense injury to violet blossoms, the cash estimate of his losses being placed at \$1,000 to \$1,200 for that year.

During the following autumn correspondence was received from Mrs. J. Sampson, Gordonsville, Va., regarding the occurrence of this species in her violet beds, this being the most troublesome violet pest in that locality.

November 19 of the same year Mr. W. D. Philbrick, Newton Center, Mass., wrote that this species, specimens of which were received, was present in his violet beds, and that they are usually noticed to be quite plentiful when the plants are first brought in under glass in the fall from the field where they are grown in the summer. This species, he reports, is most abundant on the petals of the flowers.

The following day Messrs. Thomas De Voy & Son, Poughkeepsie, N. Y., sent specimens with the information that these insects appeared in their violet houses during the summer of 1897, and that they were introduced through the purchase of plants from elsewhere. They gave considerable trouble that season, and the following year they occurred in vast numbers. Of their occurrence our correspondents wrote:

The increase of these terrible pests is not owing to neglect on our part; we have fought them constantly from propagating beds down to the present time, using tobacco smoke, soap water, and tobacco dust. These remedies hold them in check somewhat if constantly applied, but the insects appear to breed by the million in a single warm day or night. Several of the growers in this vicinity are troubled like ourselves with this pest, and it is beginning to alarm us, for it seems impossible to eradicate them from houses once infested.

December 12 Mr. John G. Bahret, Poughkeepsie, N. Y., sent specimens obtained from a neighboring greenhouse. His own greenhouse was free of the pest, but he had heard much talk concerning its great damage in his vicinity. The cold weather at the time of writing appeared to have had considerable effect upon the little pests, as they were not found in abundance.

February 27, 1899, Mr. W. V. V. Powers, Cornwall-on-Hudson, N. Y., sent specimens of the adult, taken on hothouse violets at that place.

No further complaints of injuries by this species were received in 1899 until October 18, when Dr. James Fletcher wrote that it was reported to be doing a good deal of harm to violets grown under glass by one of the principal growers of Toronto, Canada. The prominence which was given to this plant-louse in short notes and letters published in various florists' periodicals during the year 1898 led to its general identification in many greenhouses, and our correspondent was aware of the fact that the species was of serious importance in many of the large greenhouses of the United States, including those of Rochester, N. Y.

February 10, 1900, Miss Frances Roberts, Providence, R. I., sent specimens, reporting the species injurious to violets in that city. The beds of the greenhouse were stated to be in ideal condition and the

violets were planted September 15, and, though given the best of careful attention as to air, light, and water, our correspondent succeeded in obtaining nothing but "green" violets.

LITERATURE.

In addition to the technical paper by Mr. Pergande previously noted, several notes and extracts from correspondence have made their appearance in different florists' journals during the past two years in which the species has been studied from the practical side. It has also received consideration in Mr. Galloway's "Commercial Violet Culture," where it is discussed with the so-called green aphid, on pages 198-208. The chapter referred to is devoted principally to the use of the hydrocyanic-acid gas method of treatment for these aphides and has less to do with their biology, although the nature of injury is described somewhat in detail.

In the Transactions of the Royal Society of Canada (Vol. V, second series, 1899-1900, p. 228), Dr. James Fletcher states that this pest had caused much damage to violets during "the past winter," and that it had made its first appearance in Canada about 1897; and, in his "Report of the Entomologist and Botanist for 1899" (1900, pp. 177-178), he has given an account of injury in a large florist's establishment in Toronto. The loss was estimated at \$1,000. Reference to the same matter is given in the Report of the Entomological Society of Ontario for 1899 (1900, p. 110).

Prof. W. G. Johnson briefly noted injury to violets in Maryland during the season of 1900 (Bul. 26, new series, p. 81); also in the American Agriculturist for December 29, 1900, and elsewhere he has furnished some notes on the treatment of a greenhouse in Maryland affected by this plant-louse. One of the owners in this case stated that a single demonstration of this method was worth to him at least \$250 that season.

REMEDIES.

Hydrocyanic-acid gas alone is a sufficient remedy for this species. A spray of neutral soap or of water will also kill the insect. These remedies are treated in previous pages. Concerning the gas treatment, it should be said that it is due to the ravages of this plant-louse in the vicinity of the District of Columbia more than to anything else, perhaps, that the hydrocyanic-acid gas method of treatment was brought to its present state of perfection as a method of controlling insects infesting plants grown under glass. Until the adoption of this means of fumigation, tobacco, which has been in use as a greenhouse insecticide, or, more properly speaking, repellent, for upward of a century, was the remedy most relied upon. The danger of using tobacco in violet greenhouses is treated somewhat at length in an arti-

ele entitled "Combating Aphis on Violets," published by Mr. Galloway in American Gardening for November 6, 1897 (Vol. XVIII, p. 758), from which the following is quoted:

Aphides, especially the black ones, were once the most serious pests with which we had to contend. Since we have adopted the hydrocyanic-acid gas treatment, however, * * * we have had no serious trouble. So important do we consider this matter of being able to use this gas that we shall plant in the future throughout the entire season in such a way that the plants may be fumigated at any time.

We abandoned tobacco entirely some time ago, as we found by experience that, no matter how used, it would tend to weaken the foliage and make it more subject not only to "spot," but to other diseases as well. * * * When tobacco is used, either as smoke, dust, stems, or extract, it seems to in a measure check the vital functions of the leaf, the little cells of which temporarily lose their vitality and their ability to resist outside influences. Here is the opportunity the fungus needs, and it at once takes advantage of it by sending a thin, thread-like growth into the cells. Once the tissue is entered, the fungus continues to grow until the plant is able to check it of its own accord. The spot then turns white, but when conditions are again favorable the fungus will start anew, and the spot will be found soft, greenish, and watery, etc.

THE VIOLET "GALL FLY."

(*Diptosis violicola* Coq.)

Violets and roses are subject to the attack of different forms of minute larvæ or maggots, the young of what are known to florists as gall flies—minute two-winged flies or gnats of the family Cecidomyiidae. Three species are of importance as enemies of these plants, and there are doubtless others, but these three are the only ones that have obtained marked recognition by their injuries in recent years; until recently, indeed, they were not recognized as distinct from others of their kind. They have been given more or less study by the writer and by some others, and, when it was made manifest that they were undescribed through special study by Mr. D. W. Coquillett, of this office, all of the notes and manuscripts which had accumulated at that time were turned over to him, and the results were embodied in two somewhat technical articles, with full descriptions, in Bulletin No. 22 of the present series.

DESCRIPTION.

The larva or maggot, which is usually found folded up in the leaf of a violet in such a manner as to bring the upper surfaces together in what has been termed a gall, is a minute, legless creature of a whitish or yellowish color. The general appearance of one of these larvæ is shown in figure 16 at *d*, *e* representing its breastbone.

The parent gall fly is a minute, slender and delicate two-winged fly, measuring about one-twentieth of an inch in length. It has long and slender legs and antennæ, the latter 14-jointed and surrounded by two whorls of bristly hairs on joints 3 to 13, inclusive.

The general appearance of the female is shown in figure 16 at *a*, much enlarged, the segments of the antennæ being shown still more enlarged at *b*. The genitalia or sexual organs of the male are illustrated, also greatly enlarged, at *c*.

DISTRIBUTION.

It seems probable that this species, like others found in greenhouses, and in habitations, storehouses, and indoors generally, has been introduced from abroad; and it is perhaps tropical, at least in origin. The present known distribution includes the following localities: Washington, D. C.; Richmond and Gordonsville, Va.; Nyack, Tappan, and Cornwall-on-the-Hudson, N. Y.

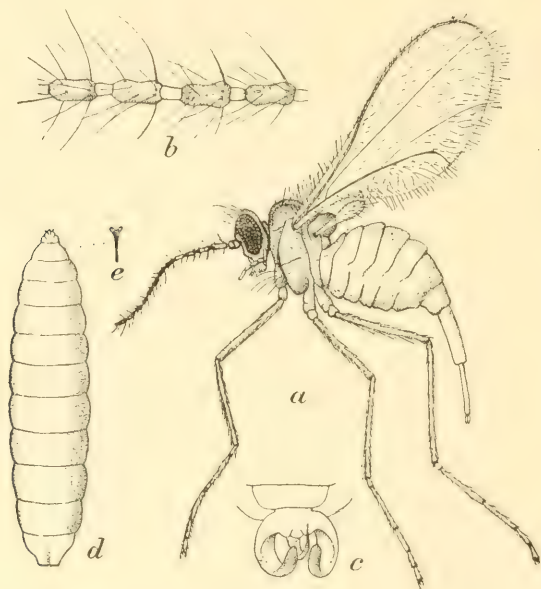


FIG. 16.—*Diplosis violicola*: *a*, female fly; *b*, female antennal joints; *c*, male genitalia; *d*, larva; *e*, breastbone of larva—*a*, *b*, much enlarged; *c*, *d*, *e*, more enlarged (from Coquillett).

This species first attracted attention in 1896, when it was noticed by Mr. Dorsett on sweet violets in the vicinity of Washington, D. C. One of our correspondents, Mr. W. V. V. Powers, writing under date of January 27, 1899, stated that he had noticed this insect three years earlier, and although he could not feel certain that there was any connection between the appearance of this pest and the introduction of the so-styled California violet, it was noticed that they both appeared the same year in his vicinity, Cornwall-on-the-Hudson, N. Y.

NATURE OF INJURY.

The maggots, as previously stated, conceal themselves in folds of the young, growing leaves, causing a distortion or curling into irregu-



LEAVES OF VIOLETS, SHOWING INJURY BY "GALL-FLY" LARVÆ—NATURAL SIZE.

(From photograph by P. H. Dorsett.)

lar shapes, such as are shown in the illustration (Plate III), having somewhat the semblance of a gall, which name has been rather generally applied to them by florists. After the formation of the "gall," what is known as wet rot is apt to set in and destroy the leaves. This has the ultimate effect of dwarfing the plants and of arresting the development of the flower buds.

From the frequency with which maggots resembling those found on the leaves of violets are found in the soil in violet houses, it has been thought that the insects live both in the soil and upon the leaves. It has been thought, also, that this pest is more apt to make its appearance in greenhouses where proper attention has not been paid to the mixing of the soil and to drainage, and that manures of some kinds favor its development. It seems probable, however, in the light of more technical knowledge of the subject that the larvæ found in soil are in nearly every case those of *Mycetophilidæ*, and probably of different species of *Sciara*, several forms of which occur in greenhouses, of which some are reported to be injurious while some are scavengers. One of these species known as the fickle midge will be treated farther on in the present publication.

LITERATURE OF THE SPECIES.

What appears to be the first account that can be with positiveness attributed to this species of "gall fly" was published in the *Florists' Exchange* (Dec. 19, 1896, p. 1132), by Mr. Dorsett. At that time it was not known that this species was different from the so-called gall flies of roses. The account in question is a short one, and is illustrated by a half-tone reproduction of a photograph showing injury to violet leaves by the larvæ. In the same publication (issue of December 3, 1898), Mr. W. Davison wrote of the occurrence of this species at Nyack, N. Y., and in *The American Florist* for January 21, 1899, Dr. L. O. Howard gave a brief summary of what was then known concerning the insect. In Mr. Galloway's "*Commercial Violet Culture*," published the same year, this species is considered on pages 211-214, injuries by the larvæ to the flowers of violet being illustrated.

The aim of the present article is to present in concise, summarized form most of the facts which have already been made public in the articles above quoted.

REMEDIES.

Hydrocyanic acid gas does not appear to have been tested against the violet gall fly, or if it has been used we have no published account of the fact. There is no reason to believe that it would be less effective than when employed against aphides and other insects. Its use is, therefore, suggested. It does not seem practical to pick the leaves, because in such cases the crowns are permanently injured and flowering is checked. Mr. Galloway suggests the use of air-slaked lime,

thrown into the crowns and allowed to reach the soil. If with this the best cultural conditions possible are maintained, such as good ventilation and a frequent stirring of the soil, injury might be greatly lessened. The free use of Buhach, or Persian insect powder, at the time when the mature gall flies are seen flying about the greenhouses and upon the windows, would also be of considerable value in lessening their numbers.

THE VARIEGATED CUTWORM.

(*Peridroma saucia* Huebn.)

Of all violet pests, other than those which have already received special mention in this publication, cutworms of several species as well as allied caterpillars of moths belonging to the same family, the Noctuidæ, and some related families, are most conspicuous. It is seldom that greenhouses are entirely free from them, and the constant vigilance of the florist must frequently be exercised to keep them under control. The leaves of violets are particularly subject to cutworm attack in the spring, after the new plants have been set out.

The cutworms in houses may be produced from eggs laid by moths which have flown in at open doors or windows, but more frequently they are carried indoors with the soil in the fall, and they are most apt to occur in beds in which grass has been permitted to grow, as well as in houses immediately surrounded by dense growths of rank grass and weeds. The reason for this is that a very considerable percentage of the cutworms which attack violets feed normally upon grasses or weeds and it is upon these plants that the moths usually lay their eggs.

Cutworms, as is well known, are most voracious feeders, and in a short time are capable of doing much damage to such small plants as violets. Frequently they cut down whole plants of these and similar ornamental flowers.

What makes these insects difficult to deal with is their nocturnal habit, their presence being seldom detected in the daytime, save by their work, unless during cloudy weather or in secluded dark places.

A common insect met with in recent years on violet and a number of other plants grown under glass is the variegated cutworm (*Peridroma saucia*). It is usually abundant nearly everywhere, and to be found in fields and gardens, pasture land, vineyards, and orchards, as well as in greenhouses. It is one of the best known of our numerous cutworms, one of the most destructive, and appears to be the particular species most often found on ornamental and other plants growing under glass in conservatories as well as in cold-frames. During the season of 1900 it was very destructive over a wide extent of territory, but most conspicuous by its injuries in the Pacific States. Owing to

its destructiveness that season, it received considerable attention at this office as well as elsewhere, and will be given more extended notice in a future bulletin.

DESCRIPTIVE.

The moth which produces this cutworm is a rather large species of the family Noctuidæ. The fore-wings are pale, grayish brown, tinged with reddish and shaded about the middle and toward the outer margin with darker brown, the pattern being variable, but more or less like the form illustrated in figure 17, *a*. The ground color of the hind-wings is iridescent or pearly white, strongly shaded about the margins with shining, light brown, the veins being of the same color and

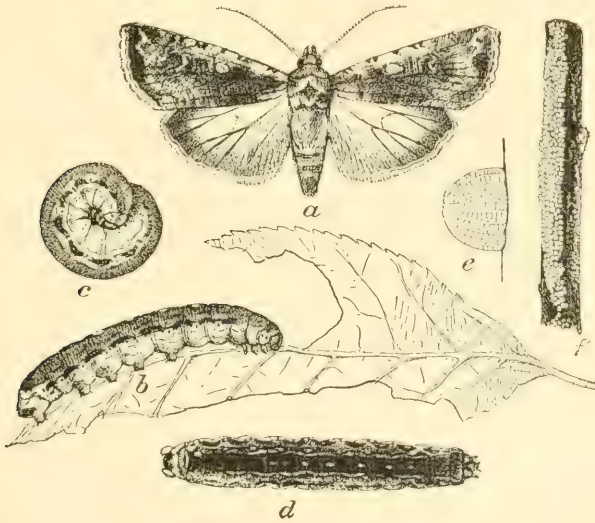


FIG. 17.—*Peridroma saucia*: *a*, moth; *b*, normal form of larva, lateral view; *c*, same in curved position; *d*, dark form, dorsal view; *e*, egg from side; *f*, egg mass on twig (after Howard).

strongly marked. The wing-expanse is about an inch and three-quarters, and the length of the body three-fourths of an inch.

The eggs are deposited in regular masses and often in rows of seven or eight or to the number of sixty or more, preferably it appears, along the twigs of certain fruit trees since egg-masses are often found in such locations. An egg is shown in profile, very much enlarged, at figure 17, *e*, and an egg-mass deposited on a twig at *f*.

The larva.—The larva is very variable, but can usually be distinguished by a row of from four to six yellow rounded spots which occur along the back at the middle of the anterior portion of the body, extending usually from the second to the fifth or seventh segment, as shown in the illustration at *b* and *d*; *d* shows a dark form, while a

lighter form, coiled in the position which the larva assumes when disturbed, is illustrated at *c*. Still lighter larvæ occur.

The pupa presents no obvious characters for description. The color is dark brown at maturity, and the tip of the body ends in a pair of minute spines.

DISTRIBUTION.

Peridroma saucia is cosmopolitan and very widely distributed over Europe, Asia, North Africa, and North and South America. In the United States it is injurious practically throughout the arable region.

During the season of 1900 injury was particularly severe in Washington and Oregon, and was reported also in Texas, Missouri, Kansas, West Virginia, Illinois, and California.

RECENT INJURY IN GREENHOUSES.

Injury in greenhouses has been reported during the past six years to roses and carnation plants near New York City, to carnations at New London, Conn., to cultivated violets at Campbell, Va., and to violets also at Charlottesville, Va. At the last place it was noticed that larvæ ate blossoms as well as leaves.

A list of ornamental plants which have been noted to be affected by this cutworm includes violets, pansies, carnations, roses, smilax, sweet pea, hollyhock, sunflower, and chrysanthemums.

Mr. M. V. Slingerland, in writing of this species and its injuries, in 1895 (Bul. 104, Cornell Univ. Agric. Exp. Sta., p. 581), says:

It would climb up the flower stalks in the evening, and, upon reaching the blossom, would firmly grasp the stalk just below with its prolegs, and then reach out as far as possible onto the petals and eat them down to the base; the outer portion of the petals which it could not reach usually dropped to the ground, often to be eaten by cutworms just coming from their day retreats. One cutworm would thus quickly damage these beautiful blossoms, and frequently two or three of them would completely destroy a whole blossom in a single night.

ON THE LIFE HISTORY OF THE SPECIES.

Considerable has been ascertained in regard to the life history of this species. In fact, we know much more about it than of most cutworms, but published accounts are somewhat conflicting, showing great variability in the life economy of the species not entirely traceable to different environment.

During recent investigations larvæ have frequently been taken during the winter when they have come out to feed on warm days. This, however, is no indication that the species does not also hibernate as a moth and also as pupa, as surmised by Slingerland and others. Egg masses that were found late in the year hatched during the latter days of October. Enough has been learned also to show that an indefinite number of generations can be produced indoors. At this

office we have kept larvæ feeding during October and November and have secured eggs in numbers during the first two weeks of January.

Dr. Riley was doubtless right when he remarked (Rep. Comm. Agric. 1884, p. 298) that his St. Louis notes on the biology of this species "indicate at least two annual generations, with a possibility of three." The climate in the District of Columbia and vicinity is much the same, and the writer feels positive that at least two generations and a smaller third generation are normally produced.

Attack begins as with most cutworms, with larvæ which survive the winter in April and May, and may continue practically without cessation until the latter days of August. The third generation is too small and makes its appearance too late to cause much trouble.

REMEDIES.

After what has been said in the introductory chapter concerning the factors which conduce to the injury of violets by cutworms, it is obvious that one of the first requisites in our efforts at controlling these pests is to avoid for use in the greenhouse soil that has grown up in grasses or weeds that may contain cutworms. To avoid this all that is necessary is to select the soil in the spring and pile it up for use in the fall. In the interim, if no vegetation grows upon the piles, the cutworms will all leave them and thus the soil will be free. This holds true to a certain extent also of some species of white grubs and wireworms, as well as some other insects. If the use of fresh soil is necessary, it should be sterilized by subjecting it to heat. It is advisable also to keep the beds as free as possible from grasses, and not to permit a rank growth of grasses or weeds to accumulate in the immediate vicinity of greenhouses and to keep the houses as tightly closed as possible, especially at dusk and at night, at the time when these moths fly about looking for suitable places for oviposition.

Careful growers keep this insect in subjection in ordinary cases by closely watching for the first evidence of attack and then searching for the insects and destroying them. During the daytime it is not difficult to find them just beneath the surface of the earth about the stems of the plants which they have attacked during the night. By digging in the soil the insects can be discovered without much trouble, and can then be destroyed.

Where fumigation is practiced many cutworms are destroyed, but for plants grown out of doors and in frames if the insects become numerous it may be found necessary to use other than mechanical methods. For this purpose poisoned baits, the standard remedies for cutworms, are the best. Green bait is prepared by spraying a patch of clover or some succulent weed with paris green, one pound to about 150 gallons of water, mowing it close to the ground, and spreading it while fresh about the plants to be protected.

Another bait, known as the bran-arsenic mash, is also valuable for the same purpose, and is prepared by combining one part by weight of white arsenic, one of sugar or a like quantity of molasses, with six of bran, and enough water to form a mash. This is distributed in the same manner as the green bait. Before setting out plants in fields which experience has demonstrated are apt to be infested with cutworms, or in new ground which has been in grass and is therefore liable to contain these insects, it is advisable to use one or the other of these baits.

THE SPOTTED CUTWORM.

(*Noctua c-nigrum* Linn.)

The spotted cutworm, which is also known as the corn cutworm, is one of the best known species of this group occurring in our country.

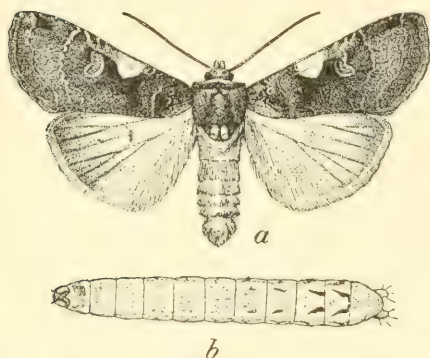


FIG. 18.—*Noctua c-nigrum*: a, moth; b, larva—somewhat enlarged (original).

Like the preceding it appears to be an introduced form, and is common to America, Europe, and Asia. It was found depredating on violets in the late fall of 1899 and 1900 in different portions of Virginia; and other complaints of injuries during the latter year have been received from Indiana, where it was injuring early cabbage and tomatoes; from Connecticut, where it had assumed the army-worm habit, and was eating a great variety of herbage, in-

cluding many cultivated plants, and in Ohio, where it was reported by Professor Webster as injurious in wheat fields in March. It was one of the common species in Maryland during the past year, and in all seasons ranks with the foremost noxious cutworms over considerable territory.

DESCRIPTIVE.

The moth.—The adult of this species of cutworm is a rather attractive and well-marked species. It has brown fore-wings, tinged with reddish in light individuals and purplish in darker ones. The anterior portion of the fore-wings is marked as shown in the illustration. (Fig. 18, a.) The reniform spot is partially suffused laterally, and at a distance of about one-third between it and the thorax is a larger triangular gray spot; back of this, and approaching the reniform, are two black, velvety spots, and there is another one on the anterior margin, near the tip. The collar is pronounced and of a gray color; the

thorax is brown and the abdomen dull gray, a little darker than the hind-wings, which are sometimes strongly infuscated on the outer margins and moderately distinctly veined. The illustration represents a male.

The egg.—The eggs may be laid singly in rows, or in compact layers, sometimes to the number of 200 or more, and when first deposited are nearly transparent, showing the green of the leaf beneath. They are nearly hemispherical in form, and strongly ribbed like many of the Noctuidæ. In consistency they are firm and elastic; each egg is about 9^{mm} in diameter, or a little more than a third of an inch.

The larva.—The young larva, when first hatched, has been described as about 0.04 of an inch (1^{mm}) in length, nearly white in color, and thickly covered with black pilosities. From these pilosities proceed black hairs, which also ornament the head and thoracic shield. The remaining molts have been described as follows by Prof. A. J. Cook (Report Michigan Experiment Station, 1890, p. 108):

After the first molt they were four millimeters (one tenth of an inch) long. A few were still white with eight pilosities to each ring and otherwise as before, while most were now plainly striped with green and white. There is a dorsal white line and two others near together on each side just above the spiracles. The pilosities are less distinct, the hairs white, and the head or under side is white or greenish-white. After the second molt they are one centimeter, or four-tenths of an inch, long. They are now lined with white, and dirty white, or light gray. A wide white stripe on each side contains the brown spiracles in its upper margin, a narrower white stripe extends along the back, while one still narrower divides the distance between the dorsal and lateral stripe about equally. The head and under surface are dirty white. In some specimens the gray is quite darkened by minute black spots, and the lateral stripes are pinkish. The hairs and tubercles bearing them are still more obscure, and as in the previous stages extend all around the body. After the next, or fourth molt, the length is nearly or quite two centimeters. The general appearance is as in the last stage except that the white lines are less clearly defined, while the gray lines are more thickly set with dark olivaceous specks which really make a dark line just above the spiracles.

The mature larva is illustrated at figure 18, *b*. In this stage it measures, when fully extended, about one and one-half inches, and five-sixteenths of a millimeter in width. It is usually an inconspicuous gray or brown in color, sometimes whitish, with strong green or olive-brown tints, and the last three or four, and sometimes all, of the abdominal segments are marked with diverging, velvet-black lines, as shown in the figure.

The pupa is of the usual mahogany brown color of most Noctuid pupæ and measures about three-fourths of an inch in length and one-fourth in diameter. The anal segment terminates in two outwardly curved spines on each side of which there are two shorter curved spines or bristles, and on the ventral surface, just above the insertion of the larger spines, are two similar, still shorter, curved processes.

DISTRIBUTION.

This species is common to North America, northeastern Europe, and northern Asia, and is probably not indigenous to our country, but was introduced many years ago, as has been known to collectors for a considerable period, and was perhaps brought from the mother country in soil about nursery stock or potted plants.

The list of localities which we are at present able to furnish is scarcely indicative of the insect's range. The following are definitely known: Schenectady, N. Y.; New Jersey, common throughout the State (Smith); Storrs, Conn.; Washington, D. C.; Marshall Hall, Cabin John, and Bennings, Md.; Richmond and Poindexter, Va.; Dayton, Ohio (Pilate); Kentland and Chesterton, Ind.; Urbana, Sheldon, and elsewhere in Illinois; Stratmann, Mo.; Volga, S. Dak. (Truman); Montana; Washington, and Oregon.

There are specimens in the National Museum, identified as this species, from Kadiak and Popof islands, Alaska, and we have larvæ, identified as this same species from Savannah, Ga. There is nothing to indicate, however, that the species is established in Alaska; in short, nothing is more likely than that the insect was transported from farther south on the coast—for example, from Washington or Oregon; and the Georgia locality is also doubtful.

With so short a list of definite localities, it is practically impossible to define the insect's geographical limits. The list alone would indicate an exclusively Upper Austral distribution, but the probabilities are that this cutworm inhabits also Transition and perhaps Lower Austral territory. A perusal of all available lists of moths might add somewhat to our knowledge. The species affords a striking example of how little we know of the distribution of some of our most common and destructive species, since this insect is to be classified with the most pernicious of its kind.

RECENT INJURY.

Recent experience with this species of cutworm begins with November 15, 1899, when Hon. G. W. Koener, Richmond, Va., sent specimens among others, that were depredating on violet beds in Louisa County of that State. The moths issued February 1, 1900.

April 2, 1900, and later this cutworm was taken, together with others, feeding on chickweed (*Stellaria media*) in a garden near Cabin John, Md. At Marshall Hall, Md., where it was found a few days later, it was the most abundant species of cutworm. From this material the moths began issuing May 10. The period of the pupal stage was found to be about four weeks—April 20 to May 18.

May 15 Mr. F. G. Dickinson, Chesterton, Ind., sent larvæ of this species, with the statement that it was one of the cutworms found there attacking early cabbage and tomatoes. He said that it was impossible

to get early plants of these crops started there owing to the ravages of cutworms. The garden had not been in grass for fifteen years, but still about half of the plants were destroyed by these insects.

In early August the spotted cutworm assumed the army-worm habit in at least one locality. August 6, Prof. B. F. Koons, of the Connecticut Agricultural College at Storrs, Conn., sent a number of living cutworms of this species with the accompanying information that they first attracted his attention in a large meadow, where they were tumbling into the water of a ditch, being particularly abundant along its border, where they fed upon weeds, ferns, golden-rod, and other plants, not cutting them, however, but eating the lower foliage. They were traveling like the army worm in considerable numbers, and not feeding upon oats or grasses, but upon netted-veined leaves. They riddled a small plot of rhubarb on the hillside near the meadow, filling the leaves full of holes, and attacked also the fruit of tomato near by. They were found also in great numbers coiled about the roots of weeds and in rubbish at their bases, and they were as abundant along the borders of the ditch as our correspondent had ever seen the true army worm, *Leucania unipuncta*. The moths of this lot, which may be considered the second generation of larvæ, began issuing about the middle of August. The pupal stage during hot weather was fifteen days.

This is the third instance known to the writer of this species assuming the habit of traveling in armies. On page 135 of the Third Report of the United States Entomological Commission, Dr. Howard states that in his investigations of the true army worm (in Illinois and Indiana) in 1881 this species was accompanied by large numbers of the spotted cutworm in the proportion of about one of the cutworms to five of the army worms. During the same year Mr. Coquillett observed this cutworm in Illinois associated with the army worm in the proportion of one of the former to eight or ten of the latter (Eleventh Report State Entomologist of Illinois, 1882, p. 51).

December 6, 1900, Mr. G. W. Morris, Poindexter, Va., sent specimens of this cutworm with report that they were devouring violets upon his place, eating both blooms and leaves of the plants.

Brief mention of the occurrence of this larva on violets in September and October in Illinois has been made by Messrs. Forbes and Hart (Bul. 60, Univ. of Ill. Agric. Exp. Sta., 1900, p. 451).

A note on the extreme abundance of this species in many localities along the north shore of Lake Ontario, where it was injurious to all kinds of garden and root crops, was given by Dr. James Fletcher in an article published in the Thirty-first Annual Report of the Entomological Society of Ontario for 1900 (1901 p. 68). The generation of larvæ found during July was in the year 1900—the one that did most harm. It seemed to take the place in Ontario of the variegated cutworm, which was injurious in the West.

LIFE HISTORY AND HABITS.

The European food plants which have been recorded for this species include *Rumex* (dock or sorrel), *Stellaria media* (chickweed), *Primula* (primrose), *Thalictrum* (meadow rue), *Epilobium palustre*, *Myosotis*, *Verbascum*, and *Lamium*.

Chickweed, in the writer's experience, is the favorite food of this as well as some other cutworms. Violets are quite subject to attack, as are also cabbage and tomato, ferns, goldenrod, rhubarb, *Lobelia*, *Helianthus*, chicory (*Cichorium intybus*), currant, celery, corn, grasses, and clover. The fruit of tomato is sometimes injured. Young larvæ devour their own eggshells, and a larva has been seen to feed upon the egg pods of locusts.

The species frequently assumes the climbing, and, less often, what is known as the army-worm habit.

It seems probable, from what the writer has been able to learn from experience and inquiry, that the larvæ are rather partial to the foliage of some fruit trees, since they are so frequently found in orchards, but the climbing habit has been noticed only in a few localities.

The life history of this species has never been fully traced, but, from the observations of Messrs. Coquillett, French, and Forbes in Illinois, it is evidently two-brooded, at least in the northern portion of that state. The imagos of the first generation appear in May and early June, and those of the second late in July and in August. It is proved beyond peradventure that hibernation takes place in the larval condition; probably only in this stage and not as pupa or moth. As an example of development in midsummer, Professor Forbes states (Sixteenth Report State Entom. Ill., 1890, p. 86) that ten larvæ, taken from cabbage July 16, entered the earth for pupation July 25 and emerged as adults August 15 to 19, these individuals having remained in the earth from twenty-one to twenty-five days. Forbes has observed that this species rarely appears at electric lights, an observation that is borne out by the writer's experience also.

Injury by this cutworm appears to be done chiefly by the hibernated or spring generation, the larvæ doing little if any appreciable damage in the autumn. In Illinois larvæ are said not to be particularly troublesome after the first part of May. Larvæ have been observed in the fields in and near the District of Columbia late in November and have been kept feeding in rearing cages out of doors exposed to the weather as late as January, in which respect this cutworm resembles *Peridroma saucia*, also a European importation.

NATURAL ENEMIES.

This cutworm being one of several species which sometimes rest during the day under stones, it is at such times sought out by parasitic insects for the deposition of their eggs.

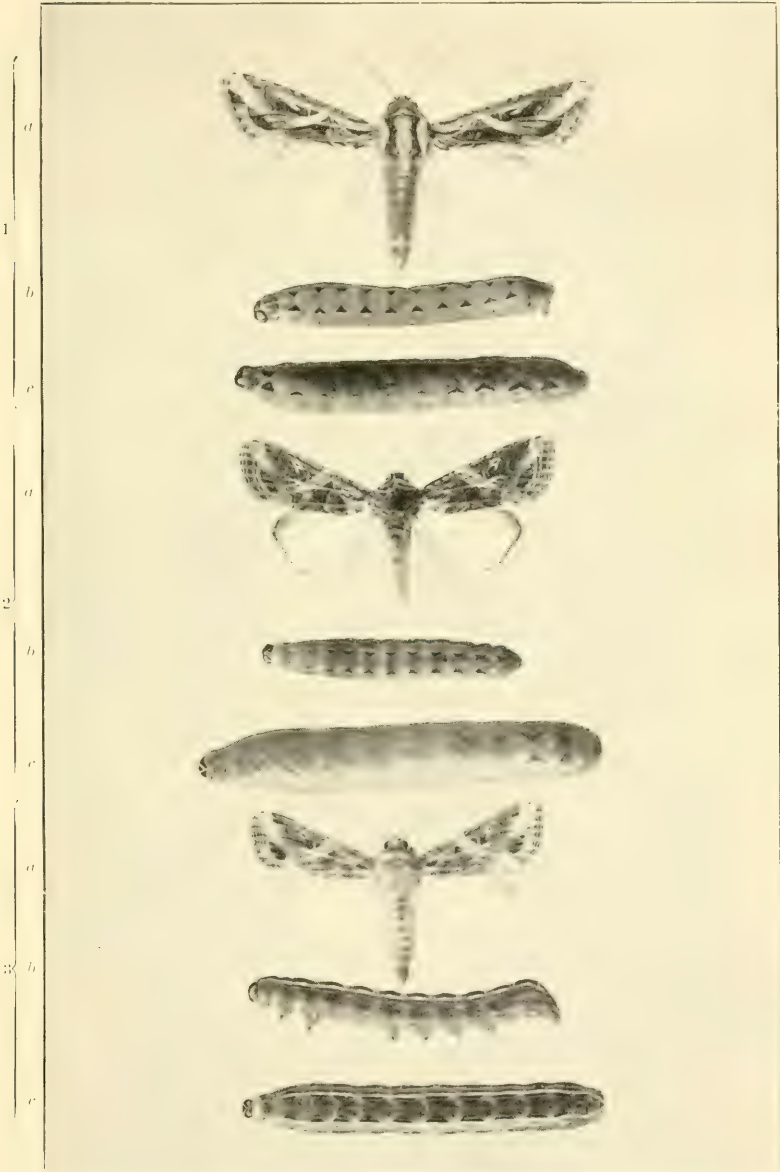


Fig. 1.—*Prodenia commelinæ*: a, moth; b, penultimate stage of larva from above; c, mature larva from side.
Fig. 2.—*P. ornithogalli*: a, moth; b, penultimate stage of larva from above; c, mature larva from side.
Fig. 3.—*P. entiopta*: a, moth; b, larva from side; c, larva from above—all slightly enlarged (original).

Ichneumon comes Cr. was reared from the pupa of this cutworm June 5, the host having transformed to pupa May 7, 1900. Locality, Marshall Hall, Md.

Apanteles sp. (near *glomeratus*) has been bred from a larva of this moth in about 60 individuals. April 7 the host larva was found dead and the parasites spun up in a white flocculent mass of cocoons, measuring a little less than an inch in diameter and half an inch in thickness. From this mass the adult parasites issued April 23.

REMEDIES.

The spotted cutworm is amenable to the same remedies prescribed for use against the variegated cutworm treated in preceding pages.

THE COMMELINA OWLET MOTH.

(*Prodenia commelinae* S. & A.)

A conspicuously marked caterpillar that preys upon violets is produced by a moth which Smith and Abbot described over a century ago under the name of *Phalana commelina*. Comparatively little is known of its food habits, but what has been learned shows that it is inclined to be omnivorous, as it has been found to be destructive to the foliage of sweet potato and cotton, and to attack asparagus and raspberry among cultivated plants. It is one of three species of *Prodenia* which inhabit the Central Atlantic States, but are more numerous in the Gulf States.

In their more northern range these larvæ appear to be more diurnal than most cutworms, and are frequently to be found in shady places in the afternoon feeding in free exposure upon their food plants. Their normal habit is evidently crepuscular and they are rather peculiarly solitary, and perhaps for these reasons they attract little attention on account of injuries. The genus, however, is well known on account of the striking colors of the larvæ as well as of the mature insects or moths.

DESCRIPTIVE.

The moth.—The adult of this species may readily be distinguished from its two more common congeners, which are here considered, by its greater wing-expanse, darker colors, and less complicated markings. The color of the fore-wings is, in fresh specimens, moderately dark rich brown, velvety in the darkest portions, where it is variegated with black in transverse lines, paler purplish brown, and dull yellow and ochreous. The pattern formed is illustrated at figure 20, *a* and figure 1 of Plate IV. The thorax is similarly colored, as is also the head, and the abdomen is paler, more uniform, grayish brown. It is rather wide and tapers strongly toward the tip. The hind-wings are pale pearl-gray with a strong violet iridescence, which is visible also on the lower

surface. The wing-expanse is about $1\frac{3}{4}$ to 2 inches (45–50^{mm}) and the length of the body is about nine-tenths of an inch (23^{mm}).

The eggs of this species, or for that matter of the genus *Prodenia*, do not appear to have been described. From preserved specimens, however, of an empty egg mass it is obvious that they are nearly duplicates of *Laphygma* in appearance, the mass itself being covered with gray hairs as in the latter genus.

The larva.—The general color of the larva is a peculiar olive or greenish brown, more or less variable, finely lined with dark gray and brown, and this as well as other species of the genus which will be discussed are all ornamented on the upper surface with a double row of triangular, velvety-black, sometimes greenish, spots, which give them a striking appearance. The larvæ are in fact so peculiarly marked that it is not at all difficult to separate this genus from any other common genus of the same family occurring in the Eastern

States. The larva of this species may be distinguished in all stages, except the final stage, by the greater number of these dorsal black spots and the lack of striation so visible in the other two. The body is cylindrical and smooth; the head is small and polished black or dark brown in front, shading off into lighter brown at the posterior end and at the sides, with the frontal triangle margined with white. The thoracic plate is dull brown or blackish with the

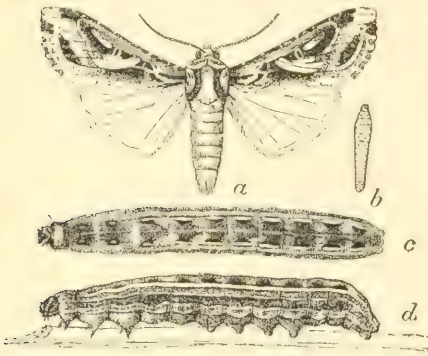


FIG. 19.—*Prodenia commelina*: *a*, moth; *b*, young larva; *c*, mature larva, dorsal view; *d*, same, lateral view—all slightly enlarged (original).

piliferous spots and median line dull yellowish, and the second thoracic segment has two usually large, deep-black dorsal spots. The dorsum is also marked with a median row of small yellow dots. The stigmata are black with pale centers, the thoracic legs brown, the abdominal legs dark green externally, and the hooklets dark brown; inflated larvæ are rather dark reddish-brown.

The length is between one and one-half and one and three-fourths inches (38–45 ^{mm}), the diameter 10–12 ^{mm}.

Technical descriptions of the various stages of the larvæ have been kindly drawn up by Dr. H. G. Dyar, and are appended.

The mature larva of a well-marked form is shown at figure 19, *c* and *d*, a young larva being illustrated by *b*.

LARVAL STAGES OF *PRODENIA COMMELINÆ*.

Stage I.—Head rounded, bilobed, shining brown-black; clypeus moderate; mouth slightly projecting; antennæ small, normal; width, 0.3^{mm}. Body slightly enlarged

at joints 3-4, and 12, cylindrical, normal, the feet small, equal, thoracic ones black. Whitish; a red-brown lateral patch on joints 5 and 11, with faint traces about tubercle iv on joints 6 to 8 of red-brown. Cervical shield distinct, transverse, slightly excavate behind, with the leg shields and tubercles brown-black. Tubercles distinct, rounded, moderate, normal. Anal shield small, brown-black.

Stage II.—Head rounded, bilobed, about as high as wide, greenish testaceous; width, 0.5^{mm}. Body shaped as before, but the shields and plates scarcely cornified, obscure, concolorous; tubercles minute, setae small. Green, the dark brown patches on joints 5 and 11 large, covering the spiracle and a small rounded subdorsal one on joint 3. Numerous longitudinal white lines consisting of dorsal, subdorsal (upper and lower), lateral, substigmatal (upper and lower); feet all pale.

Stage III.—Head rounded, wider than high, slightly bilobed, the lobes full in front, the clypeus reaching two-thirds to the vertex; greenish testaceous, a brown patch before on each lobe; width, 0.8^{mm}. Body shaped and colored as before, the region between the lower subdorsal and substigmatal lines reddish and containing traces of a supra-stigmatal white line; subventer slightly reddish.

Stage IV.—Head as before, shining brownish testaceous, clypeus rather high, two-thirds, ocelli large, black; width, 1.3^{mm}. Body cylindrical, enlarged at joints 3-5 and tapering to the head, enlarged also dorsally at joint 12. Feet moderate, equal. Shields and tubercles obsolescent, setae minute except at the extremities. Green; dorsal line narrow, white, obscure; lower subdorsal rather broad, distinct, white, shaded with orange, angled on the hump on joint 12; the two substigmatal lines parallel, waved, subconfluent by mottlings, forming a broad, sharply edged band centered with brown and shaded with orange in spots. Other lines broken, dotted, confused with strigae. Dark brown subdorsal patch on joint 3 and lateral ones on joints 5 and 11 as before. Body more or less mottled with brown between the strigae. Concolorous cervical shield cut by three white lines; thoracic feet brown; abdominal ones green, brown shielded.

Stage V.—Head as before, shining brown, reticulate with darker on the sides, the same dark color shading the clypeus, labrum, and edges of the pale paraclypeal pieces; width, 2 to 2.2^{mm}. Body as before, the enlargements less marked. Green, densely mottled reticulate with brown and whitish dots, the lines obsolescent, lost in the mottlings, except the lower subdorsal, which persists as a series of white dashes on the centers of joints 3 to 12, each dash forming the lower edge of a triangular brown-black patch, those of joints 3 and 12 the largest, the central ones smaller and sometimes not developed. A lateral patch on joints 5 and 11. Upper subventral line indicated, narrow, waved, reddish. Dorsal line indicated, distinct on joints 2 and 3. Cervical shield olivaceous brown with three pale lines; anal plate concolorous; feet greenish; slight irregular black dottings on joint 13 dorsally.

Stage VI.—Head broad, rounded, bilobed, clypeus large, reaching over two-thirds to the vertex; brown, marked as before, the reticulations not prominent; not retracted in joint 2; width, 3^{mm}. Body cylindrical, normal, gently enlarged at joints 3 to 5 and 12, tapering only at joints 2 and 13; feet moderate, normal. Densely and finely mottled with brown and whitish, the marks as before but somewhat more defined. Subdorsal velvety black triangular patches, usually subequal on joints 3 to 12, edged below by a yellow-white line, becoming a dot on joint 4, or the central ones smaller or absent, but those on joints 3, 11, and 12 persistent. Other lines obsolete or represented by traces except the dorsal on joints 2 and 3, which is narrow, pale. Cervical shield olivaceous with dorsal line only or traces of the pale subdorsal also; anal plate small, olivaceous. Black dottings of joint 13 absent in faintly marked examples. Spiracles black; feet greenish. Tubercle iv on joint 5 above the middle of the spiracle, on joints 6 to 8 above the lower angle, on 9 and 10 below the middle, on 11 halfway to tubercle v, on 12 at the lower angle of the spiracle.—[H. G. DYAR.]

The pupa is of the customary Noctuid color, mahogany brown, and is of robust form, measuring about five-eighths of an inch (16^{mm}) in length, and a little more than one-fifth of an inch (5^{mm}) in width. No characters are apparent, from a casual glance, to distinguish this genus from allied ones. The anal extremity terminates in two small divaricating processes, a character of many Noctuid pupæ.

DISTRIBUTION.

This species of *Prodenia*, as previously stated, is the rarest of the three common eastern forms, and although we have received material identified as *P. commelina* from Ashby, Mass., and it is recorded by Dr. J. B. Smith from that State, our list of definite localities appears to indicate that it is Lower Austral, and not so well established in the Upper Austral region as the other two species under discussion.

At the present writing we can furnish only the following short list of localities: "Massachusetts"; District of Columbia; Charlottesville and Colonial Beach, Va.; St. Louis, Mo.; Illinois; Macon, Ga.; Alabama; Lake City, Fla.; and Texas.

THE QUESTION OF NOMENCLATURE.

A glance at the synonymy furnished for the genus *Prodenia* by Dr. Smith in his catalogue of the Noctuidæ, published as Bulletin No. 44 of the United States National Museum (p. 169), is sufficient to show that considerable confusion exists in published accounts as to the identity of the different species. According to Smith the "wheat cutworm" mentioned and discussed by the late Dr. Riley in his First Missouri Report (pp. 87, 88), and which he again mentions and figures (as moth) in his Third Report (p. 113, fig. 48, *b*), is *ornithogalli* and not *commelina*, by which both this figure and *c* of the same illustration are designated.

This subject is discussed on page 43 of volume II of *Papilio*, as also in the Index to the Missouri Reports (p. 56).

DIVISIONAL RECORDS OF OCCURRENCES.

During recent years this species has been reported as injurious only in 1898. November 10 of that year we received from Mrs. H. B. Boone, Charlottesville, Va., specimens of the larva found feeding upon violets grown in beds at that place; but there is an earlier record of injury during the same year. This is by Mr. A. L. Quaintance, and was published in the *Farmer and Fruit Grower* of October 8, 1898, and it is evident from this account that the species is coming to the fore as a garden pest, at least in the South. The account in question relates to damage to the foliage of sweet potato by the larva of this Noctuid "throughout the State" of Florida. Reports had come in from various localities indicating that the species was widespread in its occurrence there. During feeding, the young were noticed to con-

gregate more or less on the under surface of the leaves and to eat through to the epidermis of the upper surface. With increased growth large holes were eaten entirely through the leaves, and a leaf would in some cases be completely devoured except some of the larger veins.

There are among office records two of the earlier occurrences of this species, one at St. Louis, Mo., where this species was stated to be feeding in its larval state upon the leaves of apple and peach, but in confinement only, and another dated May 13, 1884, of the receipt of specimens from Ashby, Mass., where the larva was stated to have done much damage to the buds of grape, and apple and other fruit trees; but as the moths reared are not to be found among our *Prodenias*, it is fair to presume that the person who identified the species may have been at fault. In short, there is nothing to show that this or other species of the genus ever assume the climbing habit, as is the case with the spotted cutworm, *Noctua c-nigrum*, which somewhat resembles *Prodenia* in the pattern of the markings of the dorsal surface. There is also a record of the larva identified as *P. commelinæ* eating holes into the leaves of raspberry, May 30, 1879, at Ithaca, N. Y., but it is not stated that this occurred in the field. Larvæ of this species have several times been taken on grass by the writer and others in the District of Columbia.

PUBLISHED RECORDS.

Smith and Abbot's description appeared in the year 1797 in *Natural History of the Rarer Lepidopterous Insects of Georgia* (Vol. II, p. 189, Plate XCV). The specific name was derived from the insect's food plant, *Commelina communis* Linn. We quote the original description and remarks:

Ph. *Noctua spirilinguis cristata*, alis deflexis: primoribus fusco-nebulosis litura diffracta maculaque ad apicem flavescens; posticis albidis.

Feeds on Wild Comfrey (*Commelina communis*), Hickory, Groundpeas, etc. It went into the ground August 19, and the fly came out the 10th of September. This moth, though found also in Virginia, is not very common.

The illustration furnished of the moth is quite recognizable, but that of the larva might serve about equally well for *ornithogalli* or *eudiotæ*, our other common species.

Smith and Abbot gave this species the name of *Commelina* or wild-comfrey owlet moth, and the first name we may retain for lack of a better one, since another plant, *Cynoglossum virginicum*, is the one recognized by present-day botanists as wild comfrey.

In Glover's "Manuscript Notes from My Journal" (p. 60), two references are made to *Prodenia commelinæ* in his own earlier accounts in Patent Office Reports for the years 1854 and 1855, respectively, but these accounts can not be referred to the species in question with any degree of certainty. Mention has been made by the writer in Bulletin No. 10 (new series, p. 60) of the occurrence of this species on asparagus at Colonial Beach, Va., in August.

NATURAL ENEMIES.

The habit of this larva of crawling distances in exposed situations, as, for example, across roads and sidewalks, together with its bright and conspicuous colors and large size, would seem to render it peculiarly subject to the attack of natural enemies, but as yet only one of these has been observed.

There is in the National Museum a specimen of the larva which bears upon the thoracic segments eggs of a *Tachina* fly, deposited in the usual manner transversely upon the dorsum. The adult was not reared, and no *Tachina* fly appears to be recorded as attacking this or other species of the genus.

Several times during rearing experiments larvæ that had just been taken from the field were observed to be dying of a fungous or bacterial disease, evidently the same one that is so prevalent with *Plusia brassicæ*, the cabbage looper, and similar species.

REMEDIES.

It has been reported by Mr. Quaintance (l. c.) that this species was successfully treated at the Florida experiment station with a spray of 1 ounce of Paris green to 10 gallons of water, with the addition of 1 or 2 ounces of quicklime.

Other remedies, such as poisoned baits and the like, are valuable. See account of variegated cutworm.

THE COTTON CUTWORM.

(*Prodenia ornithogalli* Guen.)

The most abundant and destructive, and consequently the best known, of the three species of *Prodenia* under discussion has been called the cotton cutworm, *Prodenia ornithogalli* Gn. Larvæ were found in considerable numbers on violet at Garrett Park, Md., during October, 1898, and were taken at intervals, although in much decreased numbers, during the following year; but in 1900 larvæ reappeared in numbers, in some cases occurring indoors as well as in the fields. The moths also returned in their customary abundance to the electric lights, where in ordinary autumn weather they are among our commonest Noctuids.

This species, like the preceding, is a general feeder, and has been noted to attack cotton bolls and the fruit of tomato in the same manner as does the cotton boll worm. In short, it has what is termed the boll-worm habit.

DESCRIPTIVE.

The moth.—The moth of this species can readily be distinguished from *communis* by the much more complicated pattern of the fore-

wings, its smaller size, and less iridescent hind-wings. The thorax lacks the two longitudinal stripes seen in *commelinae*. There is a submarginal vein of the hind-wings which shows very distinctly, and all the veins of the hind-wings, particularly the inner ones toward the abdomen, are more distinctly marked than in the preceding species. The average wing expanse is a little less than one and one-half inches (36^{mm}), and the length of the body is about seven-eighths of an inch (22^{mm}). One individual of this species taken recently measures a little less than 1 $\frac{3}{4}$ inches. There is considerable variability in the depth of coloration, fresh specimens being as dark as *commelinae*, but soon fading. The general appearance of the moth of this species is shown at figure 2, *a* of Plate IV.

In the year 1875 Dr. Leon. F. Harvey described this species (Bul. Buff. Soc. Nat. Sci., Vol. II, pp. 274, 275) under the name *lineatella*, but Dr. Smith's recent studies show that this name is antedated by Guenee's *ornithogalli*. The latter description appeared in 1852 (Spec. Gen. Noct., Vol. I, p. 163).

P. flavimedia Harv. (which is now recognized as the *c* of the Missouri figure above referred to) in like manner becomes *eudiopta* Gn.

It has several times been described in print, but a thoroughly satisfactory comparative description has not appeared.

Technical descriptions of several of the stages of the larva drawn up by Dr. Dyar are appended:

LARVAL STAGES OF PRODENIA ORNITHOGALLI.

Stage I.—Similar to *commelinae*. Whitish, the head, tubercles, and shields black. The newly hatched larva is unspotted, but toward the end of the stage the body becomes faintly green from the food with faint subdorsal, dorsal, and stigmatal white lines, a red lateral patch on joint 5, and a diffuse streak on joints 11 and 12. Head rounded, slightly bilobed, polished black; mouth squarely projecting. Cervical shield small, black, transverse, slightly pointed centrally in front. Tubercles small, black, normal, no subprimaries; ia to iib of thorax all separate, iia minute. Anal plate and leg-shields black.

Stage II.—Head rounded, slightly bilobed, clypeus high; shining translucent light brown with a reddish shade at the vertex; ocelli black. Body gently enlarged at joints 3 to 5 and 12, rather robust, normal. Green, slightly tinged with reddish especially dorsally posteriorly; a rounded, elevate, red-brown spot laterally on joint 5 and a shade on joints 11 and 12. Dorsal line white, upper subdorsal faint, lower distinct; a fainter lateral line and two parallel fine ones below the spiracle. Tubercles black, distinct, normal. Cervical shield brown, cut by whitish lines; anal shield small, dusky. Feet normal with dusky plates.

Stage III.—Head as in the next stage, pale brown, the paraclypeus pale. Body greenish, with lines as in *commelinae*, but more numerous, consisting of dorsal, subdorsal (upper and lower), lateral (upper and lower), suprastigmatal, substigmatal (upper and lower); a black subdorsal spot on joint 3, and a large elevated lateral one on joint 5. Substigmatal line, hump of joint 12 and subventer faintly shaded in vinous. Feet all pale.

Stage IV.—Head rounded, wider than high, slightly bilobed, the lobes full in front, the clypeus reaching two-thirds to the vertex, brownish testaceous, subreticulate,

the paraclypeus pale. Body normal, gently enlarged at joints 3-5, and 12, rather robust; feet small, normal. Shields membranous, tubercles and setae minute. Green, shaded with vinous brown, especially on dorsal line and subventrally. Dorsal line white, narrow, spotted with vinous shading; upper subdorsal narrow, lower broad, both white, the latter angled on the hump of joint 12; a black spot between them on joint 3. Lateral line narrow, white, with a fainter line above it; a faint suprastigmatal white line; substigmatal lines parallel, narrow, white, waved, joined into a sharp-edged band by vinous shading. Subventer faintly vinous shaded, white dotted. A square lateral black patch on joint 5. Concolorous cervical shield cut by three white lines. Feet plates brown.

Stage V.—Head as before, shining dark brown, paler on the sides, paraclypeal pieces contrastingly pale. Body as before, the enlargements less marked. Shaded with brown and vinous, obscuring the ground color, sparsely white strigose between the lines. Lines distinct generally. Dorsal line narrow, broken, vinous edged, obscure; upper subdorsal likewise narrow and reduced; lower subdorsal broad, distinct, edged above by segmentary brown patches, fainter than but similar to the one on joint 3; upper and lower lateral lines broken, mottled, but not obscured; suprastigmatal line fine and broken; subventral line narrow, waved, centered by red about as before. Cervical shield and anal plate brown, trisected in white. Feet brownish. Lateral patch on joint 5 brown-black, distinct.

Stage VI.—Head broad, rounded, bilobed, clypeus large, reaching over two-thirds to the vertex; brown, dark on the face, cut by the pale contrasting paraclypeal pieces. Body cylindrical, normal, shaped as in *commelinæ*. Densely and finely mottled with whitish dots on a brown ground, the marks as before but better defined. Dorsal line diffuse, red, obscurely pale centered; subdorsal distinct, broad, yellowish white, faint on joint 2, surmounted by a row of triangular brown spots on joints 3-13, cut pulverulently by the broken upper subdorsal and separated by pale intersegmental shades. Lateral area on joints 5-12 marked by upper and lower lateral lines, the lower broader but both subconfluent by mottlings with each other and the lower subdorsal, scarcely developed on joints 2-4 or 13. A faint suprastigmatal mottled and broken line. Substigmatal band, broad, red, white dotted, edged by the narrow lines; subventer white dotted. Shields and plates pale brown, the cervical faintly trisected by white; spiracles black. A brown patch on joint 5 between the lower lateral line and spiracle. Tubercular formula as in *commelinæ*. [H. G. DYAR.]

From the description which has been given of the larva of *commelinæ* in treating of that species, enough has been said to show that the principal difference between these two species consists in the greater striation of *ornithogalli* and in the fact that the dorsal velvety spots are many of them lost in the last two molts. The question of the separation of these three forms of larvæ can best be expressed in tabular form as follows:

Ground color gray, closely streaked with fine, very irregularly undulating lines.

Upper line of latero-dorsal stripe always interrupted, usually yellow, the lower line faint or absent.

Longitudinal stripes not strongly marked *commelinæ*.

Ground color similar.

Upper line of latero-dorsal stripe, usually more or less continuous, often white or very pale yellow, lower line distinct, though narrow.

ornithogalli.

Ground color darker, and all stripes and other markings more pronounced and more beautiful, but the arrangement is little, if at all, different.

eudiopla.

The penultimate stage of the larva of *ornithogalli* is shown at figure 2, *b*, of Plate IV, and the final stage at *c* of the same figure. The length of the mature larva is from one and one-half to one and three-fourths inches and five-sixteenths of an inch is the width (of inflated specimens). It should be added that the figures presented of this larva are not as good as could be desired partly on account of their imperfect inflation.

DISTRIBUTION.

According to specimens in the National Museum, Divisional records of occurrence, and such few published records as have been consulted, it is obvious that this species is widely distributed through the Upper and Lower Austral life zones from Massachusetts and New York southward to Texas and westward to California. In New Jersey it is credited by Smith as occurring "throughout the State," and the New York locality is recorded by Harvey. Its occurrence in the latter state, however, does not appear to be noted in any of the fifteen Annual Reports of Doctors Lintner and Felt that have appeared to date, and as no definite locality in that State or in Massachusetts has been specified it would seem that the species is rare so far north, if, indeed, it occurs there at all in the larval condition. The same holds good for Minnesota, where the moth has been captured. This species is evidently one of several comparatively well known Lower Austral forms of moths which are able during the summer and autumn to extend their range, principally by flight, well into the Upper Austral region, where occasionally, as happened in 1889, numbers succumb during severe winters.

The list of localities which will be given, though short, may serve as a basis for additions which will indicate more clearly the range of this insect: New York; New Jersey; Lancaster, Pa.; Berwyn, Cabin John, Garrett Park, Md.; Tennallytown and Brookland, D. C.; Dayton, Ohio (Pilate); Lafayette, Ind.; St. Anthony Park (Lugger), Tensas Parish, Ashwood, La.; Holly Springs, Miss.; Archer, Fla.; Gainesville, Tex.; Lawrence, Clay County, Kans.; Fountain, Okla.; St. Francis County, Ark.; Savannah, Griffin, Ga.; Raleigh, N. C., and California.

RECENT OCCURRENCE.

This species has come under observation quite frequently during the past three years through the occurrence of larvæ upon cultivated and other plants. Prior to this date and during 1898 the moths were quite frequently seen at electric lights, particularly during autumn, but in 1899 there was a considerable diminution in their numbers, as has been related elsewhere, while in 1900 the moths returned to lights in numbers approximating their former and normal abundance.

During 1898 several larvæ were brought to the office at different times in late August and early September by Mr. P. H. Dorsett found feeding upon violets at Garrett Park, Md., and were also taken by the writer upon potted violets on the Department grounds. A larva which was nearly full grown September 6, 1898, and which entered the ground a day or two later, issued as moth October 16. From larvæ obtained from the same source September 29 moths were obtained November 10. A larva received on greenhouse violets October 14 issued as a moth in a warm room January 7, 1899.

During 1899 this larva was met with on only two occasions, early in September, when the species was found feeding upon the hogweed, *Amaranthus retroflexus*, on the Department grounds. A moth from this lot was reared September 27, 1899.

October 7 three larvæ were taken by Mr. Pratt on asparagus in the District of Columbia.

June 11, 1900, Mr. T. C. Knoop, Fountain, Okla., sent larvæ of this species with report that they were injurious to garden plants, and especially to cabbage. They were noticed in great numbers in the evening, and were seldom found during the day. They were stated to have destroyed several thousand plants on our correspondent's farm, necessitating much replanting.

July 1 a larva taken on tomato at Cabin John, Md., was one-fourth grown. At the end of a week it was three-fourths grown. The moth issued July 28. July 9 a larva was observed attacking cucumber at Cabin John, Md.

Larvæ were subsequently taken about Washington, D. C., at intervals in late September and in October, on tomato and on morning glory, moths from which issued as late as the latter days of November.

October 13 Mr. H. Walter McWilliams, Griffin, Ga., sent the larva with report that these "worms" were destroying ruta-baga turnips, field-pea vines, rape, and everything belonging to the cabbage and pea families of plants. The specimen received bore numerous eggs of a *Tachina* fly on the head and thorax.

EARLY DIVISIONAL RECORDS.

Our office notes concerning this species begin with the date August 27, 1881, when we received larvæ taken at Savannah, Ga. March 10, 1882, we received from Mr. Albert Koebele, Archer, Fla., a larva taken in a cotton field.

Eggs obtained from a moth of this species taken in the District of Columbia August 22 hatched on the 25th.

June 30, 1885, a larva was received from Mr. J. H. Ragsdale, Gainesville, Tex., where it was found feeding on cotton.

May 1, 1888, we received a lot of larvæ from Mr. F. M. Webster, at that time at Ashwood, La., found depredating on corn and cabbage.

The lower leaves of corn were first attacked, and then the "worms" fed on the tender unfolded leaves higher up.

June 30 of the same year Mr. Webster again sent the larvæ of this species from Lafayette, Ind., where it was also found feeding on corn.

October 28, 1890, we received the larva from Mr. F. W. Mally, Holly Springs, Miss., where it was found feeding on cotton.

June 6, 1896, we received the larvæ from Prof. F. H. Snow, Lawrence, Kans., with the report that they were destroying late-planted corn in Clay County of that State, eating both leaves and stalk down to the ground.

We have also obtained the larva from Raleigh, N. C., reported on cottonwood.

Some of the above facts have been briefly repeated by Mr. Webster in Bulletin 45 of the Ohio Agricultural Experiment Station (p. 187).

ECONOMIC LITERATURE.

This species has received comparatively little attention in economic literature. In the Tenth Report of the State Entomologist of Illinois (p. 139), Mr. John Marten makes mention of the feeding of the caterpillar on salsify. This note, however, was based upon observations made in confinement, and there is no evidence to show that the insect sought the salsify from choice.

In *Insect Life* (Vol. II, p. 382) Mr. F. M. Webster notes the occurrence of full-grown larvæ at Lafayette, Ind., October 29, 1888. In the same publication (Vol. III, p. 149) Mr. Webster states that the larvæ were observed in considerable numbers in April, 1888, in Tensas Parish, La., depredating upon young corn. They were also observed the same month riddling the leaves of cabbage in gardens, as also in St. Francis County, Ark., ravaging fields of potatoes, eating every vestige of a leaf from them. June 26, of the same year, young larvæ were observed at Lafayette, Ind., feeding upon the parenchyma of leaves of wheat, and a few days later upon cabbage. Still later they were feeding upon the foliage of late-planted corn.

In Bulletin 24 (o. s.) of this Division (p. 24) Mr. F. W. Mally notices the occurrence of the larva on cotton and states that it enters nearly grown bolls, feeding on their contents in much the same manner as the boll worm. Mr. Ashmead also noticed this species feeding upon cotton bolls and records the fact that it had been observed attacking young cotton plants as they appeared above ground, acres being sometimes destroyed and having to be reset to secure a good crop. The pupal stage was ascertained to be between twelve and thirteen days in August in Mississippi (*Insect Life*, Vol. VII, pp. 324, 325).

The occurrence of this cutworm upon asparagus at Berwyn, Md., and in the District of Columbia, in August and September, 1896, has been recorded by the writer (Bul. 10, new series, p. 60).

This is one of the common caterpillars in Illinois beet fields, according to Messrs. Forbes and Hart (Bul. 60, Univ. Ill. Agric. Exp. Sta., 1900, pp. 496-497), being found most abundantly in the caterpillar state in July and August.

FOOD AND OTHER HABITS.

A list of larval food plants has been compiled by Messrs. Forbes and Hart which includes besides cotton, beets, corn, wheat, cabbage, potato, asparagus, salsify, peach, and raspberry. To this list may now be added the foliage of violets, asparagus, cucumber, tomato, morning glory, turnips, pea, rape, ruta-baga, pigweed, cottonwood, and grasses. It seems probable that many more plants will be added in course of time. Injury has also been noted to the bolls of cotton and fruit of tomato.

Our knowledge of the life history of this cutworm is so limited that little can be said about it. What we know, however, applies about equally well to the other two species under consideration.

The moth does not appear to have been captured or reared earlier than July 28 in the District of Columbia. In cold rooms in confinement moths have bred out at intervals during the winter, and one was present in our rearing jars, and active when stimulated, February 2. It is evident that moths develop in the field as early as the last week of July and irregularly from that time, according to the state of the temperature.

The species is credited with being double-brooded, and of this there can be no possible doubt. It is more probable, however, that three generations are produced in the District of Columbia and farther South.

When fully matured the larvæ enter the earth to a very moderate depth, according to the writer's observation, and form, at least for the last generation or hibernating pupa, a tolerably compact, serviceable cocoon, moderately lined with silk and outwardly covered with sand or earth. The winter, according to Riley, is passed generally in the larval stage, but sometimes also as pupa or imago. Recent observations do not uphold this theory, since the climatic conditions are much the same in Missouri as in the District of Columbia and vicinity. In the latter locality larvæ have never been found hibernating, and it is probable that the pupæ would pass the winter under suitable conditions, but the imago often hatches out, as previously stated, at times during the winter, and it does not seem probable that all of the individuals which issue in cold weather survive cold spells.

NATURAL ENEMIES.

Mention has already been made of a *Tachina* fly parasite of the larva.

Limneria sp.—A larva was brought to this office June 13, 1899, by Mr. T. A. Keleher, who found it feeding upon tomato. It was at

this time only about one-fourth grown, and it was somewhat surprising to find that a parasite issued from it in a few days and spun up its cocoon June 18. The adult parasite issued June 26.

Copidosoma truncatella Dalm.—A *Prodenia* larva of this species found on tomato September 20, 1900, was noticed to be infested with this minute Chalcidid, which issued later.

REMEDIES.

The remedies are the same as for the variegated cutworm and similar species.

THE EUDIOPTA OWLET MOTH.

(*Prodenia eudiopta* Guen.)

The moth of this species, until recently labeled in collections *Prodenia flavimedia* Harv., is nearly as often met with in the District of Columbia as the two preceding species, but until the past year the larva does not appear to have been so often observed attacking useful plants. It has not yet been identified with attack upon violet, but since it is so closely related to the other two *Prodenias*, and especially to *ornithogalli* Guen., from which indeed it can sometimes be separated only with difficulty, it may appropriately be considered in connection with the other two forms mentioned. During the year 1900 larvæ were several times taken on tomato, into the fruit of which they sometimes bore after the manner of the boll worm.

DESCRIPTIVE.

The moth.—The closeness with which this species approximates *ornithogalli* is such that it leads to the suspicion that they may be only dimorphic forms of the same species, a matter which could perhaps be satisfactorily determined one way or the other by rearing from the egg, an experiment which we hope to perform the coming season. The differences, indeed, are much less striking than are those of the two common forms of *Laphygma frugiperda*. The most striking character is the brighter coloration of the fore-wings, the ground color of which is more or less ochreous. The body is lighter, with an ochreous tint particularly marked at the tufted extremity. The apex of the fore-wing is well marked with whitish, as is also a little area about the tornus. The oblique band which crosses the fore-wings from near the middle of the costa toward the tornus is wider and pale yellowish, and the space between this and the dorsum is variegated pale brown. The size is about the same as *ornithogalli*.

This moth is shown at figure 3, *a*, of Plate IV.

As to the validity of this species it may not be out of place to quote the language of Professor Riley in discussing these three species.

Speaking of "*Prodenia commelina*" (= *ornithogalli*), he wrote (Papilio, Vol. II, p. 43):

With the well-known varieties of *Laphygma frugiperda* in mind, I have been particularly interested for a good many years in breeding this *Prodenia*, and I record here my belief, which will be the accepted belief in the future, that *flavimedia* and *lineatella* are one species not distinct from *ornithogalli* Guen. The larvæ, so far as I have bred material, are extremely variable and not separable, and the same may be said of the mature insects. They are more readily separable from the typical *commelina*, though doubts even as to their specific distinctness from it are justifiable.

In case *ornithogalli* and *eudiotra* should prove to be varieties, the former name would take precedence, as it was described first, although in the same publication.

The larva.—The general color of the larva of this species in its last stage is much darker than that of the two forms previously mentioned, the triangular spots in most individuals being velvet-black. The dorsal line is reddish-brown; the latero-dorsal stripe is bright canary-yellow, its upper fourth or third and lower sixth or eighth forming distinctly separable stripes within the main stripe, and inclosing a third duller stripe streaked longitudinally with undulating olive-brown; the lateral or stigmatal stripe just below this is a little narrower, and so closely streaked with black as to appear uniformly black except under a magnifier. The latero-ventral stripe is of about the same width as the lateral. It is light yellowish-brown dorsally, and darker brown below, mottled with white. The ventral surface of the body is olive-brown, greenish-olive medially, mottled with white.

The difference between the larva of this species and that of *ornithogalli* may perhaps prove to be of a varietal nature only.

The length of the larva (inflated) when fully matured is about one inch and three quarters (45 mm), and the width a little over a fourth of an inch (7-8 mm). An illustration of the larva, dorsal view, is given in the last object figured in Plate IV (fig. 3, *c*), the object above it (*b*) showing the lateral view of the penultimate stage.

DISTRIBUTION.

The distribution of this species appears to be the same as for the preceding, any difference that may exist, so far as our records go, being accountable for the fact that this form is liable to be confused with *ornithogalli* by those not perfectly familiar with both, as well as by the somewhat greater scarcity of the present species. In New Jersey *eudiotra* is credited by Smith with the same distribution as *ornithogalli*. It is common in the District of Columbia, and the moth is frequently taken at lights. It has also been reported at this office from St. Elmo and Falls Church, Va.; Kirkwood, Mo.; Texas and California, and it has been recorded from Massachusetts, New York, Dayton, Ohio (Pilate), and Nebraska.

RECENT OBSERVATIONS.

In recent observations this species has come under notice as follows:

July 20, 1899, a larva was taken feeding on the leaves of pokeweed, *Phytolacca decandra*, growing in the Department Insectary. This larva ceased feeding and entered the earth July 23, the moth issuing August 6.

August 10, 1900, Mr. Nathan Banks brought larvæ of this species from Falls Church, Va., less than one-fourth grown, feeding upon tomato. They fed most voraciously in confinement, and in three days had completed growth, entering the earth on the 13th and 14th of August, the adults issuing August 29.

August 16 Mr. Pratt brought a larva found at St. Elmo, Va., boring into tomato. As was to be expected, this individual was very much paler than normal, and the triangular dorsal spots were also pale and inconspicuous. This larva at once bored into a tomato when provided with one.

Larvæ were subsequently found and reared to moths on tomatoes growing in the District of Columbia. One of the larvæ kept under observation entered the earth August 31, and the imago issued September 15. Moths were obtained at lights in the city as late as the 31st of October.

Nothing can be found by the writer at the present time, in all the literature which has been consulted, concerning the biology of this species, and the same is true of our Divisional notes.

The larvæ, like those of the preceding species, have frequently been observed crawling about the grounds of the Department of Agriculture and elsewhere in the vicinity of the District of Columbia, and we have one record of the larva feeding on turnip, one of its feeding upon "bushberry," and another of attack on castor-oil plant.

REMEDIES.

For a consideration of the remedial treatment to be observed in the case of attack by this species the reader is referred to the article on the variegated cutworm.

THE FALL ARMY WORM.

(*Laphygma frugiperda* S. & A.)

The first occurrence of the fall army worm or "grass worm" on violets that appears to be recorded in our notebooks is dated August 9, 1897, when we received from Miss Louise Morris, Athens, Ga., the report that the species was injuring violets at that place, and that there were thousands of the caterpillars in the grass near by. The following month we received larvæ from Garrett Park, Md., where they were found on greenhouse violets.

As it is evident that this species has a fondness for violets among greenhouse plants, growers would do well to keep a lookout for it in times of its abundance on grasses and other outdoor plants.

A general account of this insect, with illustrations of the larva, pupa, and imago, was given on pages 78-85 of Bulletin No. 23 of the present series; and, as a more detailed account of it will shortly be published, further mention may be omitted for the present.

The remedies applicable to this species are the same as for the variegated cutworm, at least as far as the occurrence of the fall army worm in greenhouses is concerned. A consideration of remedies to be used when this species is destructive in the field was given in the bulletin cited.

WHITE GRUBS.

Several other common greenhouse pests besides those which have already received special mention are often injurious to various plants grown under glass, and are occasionally troublesome to violets by attacking their roots. Among these are white grubs and wireworms. Complaints of both forms of insects have recently been made, but unfortunately the species concerned in the injury have in no case been identified, it being a difficult matter to rear these insects from material which has gone through the mails, principally because they need the best of care and attention, and require as well a considerable period for their development, extending in some cases over a period of three years. Nearly every florist is familiar with white grubs, but he may not know that there are several hundred different forms of these creatures, each representing a different species of the family Scurabaidae or Lamellicorns. Fortunately only a small portion of the white grubs are of prime importance economically, the remainder not attacking living plants. The destructive forms subsist upon roots under sod and about weeds and various cultivated plants, and most of these, the typical white grubs, belong to the genus *Lachnosterna*. They are brought into greenhouses in pots of earth, and occasionally in manure, but as a rule the species which breed in decomposing matter, such as manures, are much less destructive than the species of *Lachnosterna*. The different species can be distinguished from one another only by careful study, and for practical purposes it will not be necessary to consider this subject in detail in the present bulletin.

The species of white grub shown in the accompanying illustration, (fig. 20), may be taken as a type of this class of insects. The grub itself, illustrated at *c*, is of large size, of soft consistency, and white or slightly yellowish in color. The body is wrinkled, covered sparsely with fine hairs, and the head is brownish and armed with strong mandibles.

This, as well as other grubs of the same class, habitually rest in the curved posture illustrated. The parent beetle, shown at *a*, is a large

species, dark shining brown in color, and, like others of its kind, familiar to nearly everyone from its habit of flying into lighted rooms in late spring and early summer, where it buzzes and bumps about upon the ceilings until it drops sprawling to the floor. The antennae or feelers are jointed and terminate in a club composed of seven leaf-like plates, folded closely together when the beetle is resting and expanding somewhat like a fan when the insect is active. The club of the male antennae is usually considerably longer than that of the female. The form figured, *Lachnosterna arcuata*, is a Southern one, and common in a climate like that of the District of Columbia. Here these creatures occur from about the middle of April into June, being most abundant in May; hence the name of May beetles. Farther north they are more abundant in June, and are there called June beetles. They are familiar objects at electric lights in most cities.

The life history of a white grub of the genus *Lachnosterna* may be given in general terms as follows: The sexes pair soon after their first

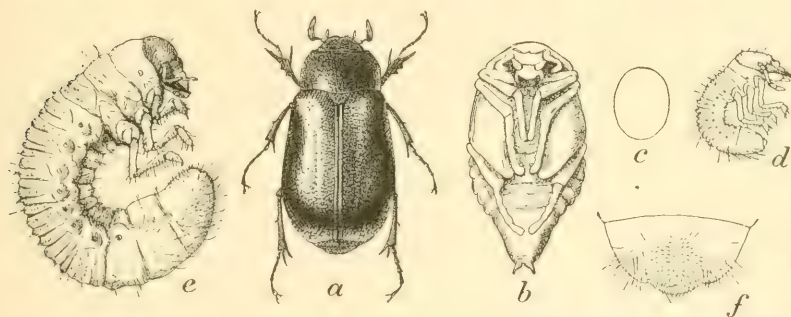


FIG. 20.—*Lachnosterna arcuata*: a, beetle; b, pupa; c, egg; d, newly-hatched larva; e, mature larva; f, anal segment of same from below. a, b, c, enlarged one-fourth; e, d, f, more enlarged (author's illustration).

appearance, whether in April or later in May or June. The females enter the earth and there deposit singly their rather large whitish or gray-colored eggs, one of which is shown in outline at c of the figure, each in a separate cell, and usually at a depth of from 2 to 4 inches. The grubs hatch and feed upon the roots of grasses and similar plants—first upon rootlets, and afterwards on larger roots—living in the earth, and slowly increasing in size for a period of two or three years. Transformation to pupa in a normal outdoor condition usually occurs from about the middle of June to September of the second or third year after hatching, the beetles developing in August or September of the same year. These remain in the earthen cells in which the pupal transformation took place until winter has passed, sometimes at a depth of a foot or a foot and a half below the surface, where protection from cold and frost is obtained.

Hibernation may occur in two stages of the larva and occasionally in a third, as well as in the beetle state, and some variation as regards the insect's life economy is to be expected in the higher temperature of a greenhouse.

White grubs are preyed upon by a host of natural enemies, including other insects, parasitic and rapacious, birds, mammals, and Batrachians. In the last class toads are the most efficient, and they are sometimes utilized for the purpose of destroying insects in greenhouses.

REMEDIES.

The habit of white grubs of passing the greater part of their existence underground and at a considerable depth renders it a matter of difficulty to reach them with insecticides. Against some forms bisulphide of carbon, kerosene emulsion, and poisoned baits have been used with some success. For use in greenhouses the best remedy, everything considered, is the poisoned baits. Of these, one of the best is the bran-arsenic mash, which has been mentioned in connection with remedies used against cutworms. In addition to the use of this mash, it is always advisable to pursue the cleanest of cultural methods, the same as has been advised against cutworms, which includes the avoidance of fresh soil which might contain these creatures, the keeping down of all grasses in the immediate vicinity of greenhouses, and particularly in the soil in the greenhouse itself. The use of fertilizers is also advisable, as it enables plants to resist insect attack at the roots.

Sterilizing the soil by means of heat or steam is also of value.

As manures are frequently infested by white grubs, and some of these are at times troublesome, it is well to exclude such forms as experience has shown contain an excess of these creatures—as, for example, horse manure. They can be identified readily by disintegrating the material, and chickens and other fowls could be utilized in destroying them before the manure is used in the greenhouses.

WHITE GRUB OF THE GREEN JUNE BEETLE.

(*Allorhina nitida* Linn.)

Complaints are frequently received from correspondents of injury by the larvæ of this species, but in most cases there are reasons to believe that the damage is really done by cutworms or some other insects, and the white grubs, on account of their large size and their habit of crawling about on the surface of the ground, are blamed for the misdemeanors of the other species.

An instance which was probably of this character was reported to this office November 21, 1898, by Mr. W. E. Pray, Kinkora, N. J., who sent specimens with report that this "grub-worm" was troublesome

in his violet houses. The larvæ were first noticed soon after the plants had been put in bed, and at this time they seemed to do very little if any harm, but the ground was described as being "kept well cultivated for two inches deep by their movements." As the plants grew the larvæ were stated to begin to feed upon the fibrous roots, and were so doing at the time of writing. They were also stated to devour the outside petals of the flowers which rested upon the ground and very frequently ate into the hearts of the flowers, rendering them unfit for shipment. Specimens of violets showing the alleged work of this species were received with the white grubs. A great number of the flowers were described as having been destroyed, and a remedy was requested.

From the nature of the description of the injury there seems to be little doubt that cutworms were the authors of the damage in the case above cited.

WIREWORMS.

The term wireworm is applied to numerous forms of elongate wire-like creatures, the larvæ of snapping beetles or "snap-bugs," beetles of the family Elateridæ. Many of these species are injurious to cultivated crops and are often troublesome in green-houses to plants of various kinds, including violets. As with white grubs, however, and for the same reasons, the exact species causing this form of injury to violets have not been determined.

The writer has in mind one complaint made of the ravages of wireworms to violets at Arlington, Md., reported to this office November 25, 1898, by Mr. James K. Marks, jr., who stated that the insects were giving a great deal of trouble, a remedy being desired.

A common form of wireworm in the field and one that has been identified as occurring also in greenhouses is the species figured herewith, known scientifically as *Agriotes mancus* and popularly as the wheat wireworm. It was received during April, 1898, from Mr. Milan C. Moulton, York Corner, Me., with report that it was injurious in a greenhouse there, cucumbers being attacked when no other plants were in the house. In the illustration (fig. 21) *a* represents the

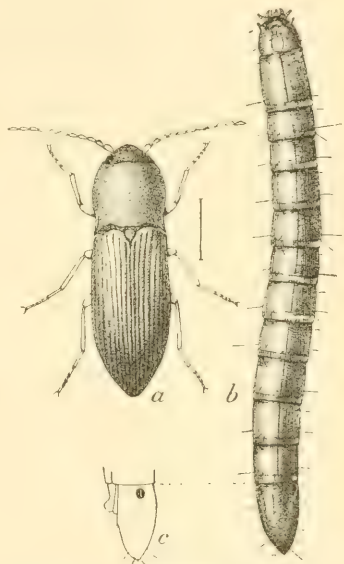


FIG. 21.—*Agriotes mancus*: *a*, beetle; *b*, larva; *c*, anal segment of larva in profile—about 4 times natural size (original).

beetle, four times natural size; *b* the larva or wireworm, and *c* the anal segment of the same in profile.

A large proportion of these wireworms are shiny yellow in color, and the present form is no exception, while many of the adults, like the species figured, are brown and covered with close brown or yellowish pubescence.

The life history of injurious subterranean species is in some respects similar to that of white grubs, the beetles being among the earliest spring arrivals, occurring in April and May, flying rapidly in the heat of the day.

The eggs are deposited by preference in moist places grown up with grassy vegetation, weeds, or corn, and the larvæ upon hatching feed, like the white grubs, upon the roots, developing slowly and requiring about the same period for the perfection of the life cycle—about two or three years. Like the white grubs, also, the wireworms transform to pupæ in autumn, and change to the beetle form takes place before winter, the beetles usually remaining in a quiescent state until their emergence the following spring.

In the warmer temperature of the greenhouse this life cycle might vary somewhat from the normal cycle out of doors.

REMEDIES.

Owing to the extremely hardy character of the larvæ, indicated by the hard, firm texture which has given them the name of wireworms, as well as to their subterranean nature, these insects are even more difficult to treat satisfactorily than the white grubs.

Of direct applications, poisons are of little value, but salt in large quantity has been used by some persons with success for many years, and has been reported to be one of the most effective applications that can be made. Strong brine, it should be stated, must be used with caution, as it sometimes destroys certain forms of plant life.

Different forms of salty fertilizers are also said to be of value, both as stimulants to the affected plants and as insecticides. Among these are kainit and nitrate of soda.

The sterilization of the soil, clean cultivation, and poisoned baits are also indicated, the same as for white grubs. In fact, where remedial measures are in use against either cutworms or white grubs, they apply about equally well to wireworms.

One of the best forms of bait to be used consists of slices of potatoes or other vegetables poisoned in the same manner as advised in the consideration of the variegated cutworm.

MISCELLANEOUS INSECTS INJURIOUS TO VIOLETS.

A perusal of available literature shows some additions to be made to the list of the different species of insects which have been treated in preceding pages in connection with their attack upon the violet, and some insects are also mentioned in the files of this office, which have not been recorded as attacking this plant.

“*Green Aphis*.” Two and probably more species of aphides affecting violets are known to growers, but only two have been identified specifically. These are the plum plant-louse, *Myzus malabab* Fonse., which was treated on pages 52–59, Bulletin 7 of the present series, and *Rhopalosiphum dianthi* Schrank. The first of these was received November 19, 1898, from Mr. W. D. Philbrick, Newton Center, Mass., who stated that these plant-lice were usually noticed to be quite plentiful when the violet plants were first brought in under glass in the fall from the field where they are grown in the summer. This form is usually found on the underside of the large old leaves near the ground. During January and February, 1899, specimens were received from Mr. F. B. Boone, Charlottesville, Va., found on violets grown under glass. May 2, of the same year, Mr. Galloway brought specimens which were present upon violets, *Scrophularia* and *Capsella bursa-pastoris*, at his place.

A comparison of the nature of injury by the green aphides which attack violet and the brown or black aphis is made by Mr. A. F. Woods in a statement that the latter produces a marked stunting of the plants, while the former does little injury outside of distorting the flowers (Bul. 19, Div. Veg. Phys. and Path., p. 24, 1900).

Rhopalosiphum dianthi Schrank. was received November 21, 1898, from Mr. W. C. Pray, Kinkora, N. J., who sent two apterous specimens found upon violets at his place. These plant-lice were described as causing the flowers to turn white in spots by suction of the juices from the parts affected.

The “syringing,” or, more properly speaking, spraying, to which violet plants are subjected two or three times a week to keep them free from “red spider,” also serves to suppress or to at least keep down the number of aphides, and it is perhaps this remedy more than anything which has held in abeyance the so-called green aphides of violets.

A scale insect on violets.—A scale insect known as *Dactylopius virgatus* is on record as attacking violets (Insect Life, Vol. V, p. 247).

Butterfly caterpillars.—A considerable number of butterflies of the genus *Argynnis* subsist in the larval condition on wild violets, which is their normal food plant, and these and related species which attack wild violets are liable at any time to attack cultivated plants. Among related species which have similar habits is *Melitaea editha* Boisd.

The variegated fritillary (*Euptoicta claudia* Cram.).—One of this group of butterflies, the Nymphalinae, is the species above mentioned. July 2, 1900, we received a number of caterpillars of this species from Mr. Willie A. Toole, Baraboo, Wis., with report that they were found on young pansies and were numerous enough to cause some damage. Writing again October 27 our correspondent stated that this species was very plentiful during the year, more so than in the preceding season, and expressed the opinion that if it continued to increase as it had done it might become a serious pest. During the past season the butterflies paid in part for what injury the caterpillars had accomplished, in the fertilization of the pansies—bumblebees, the insects which usually bring about this result, having been unusually scarce.



FIG. 22.—*Euptoicta claudia*: a, mature butterfly; b, caterpillar; c, pupa—all natural size (original).

A full account of this species has been given by Dr. S. H. Scudder in his "Butterflies of the Eastern United States and Canada" (Vol. I, pp. 519-527) where the different stages are fully described and figured, and other obtainable facts are detailed. The life history, however, is still somewhat incomplete. A shorter account is given in Dr. W. J. Holland's "Butterfly Book" (pp. 99, 100).

This butterfly varies in the depth of markings as well as in size, the wing expanse being from an inch and three-fourths to two inches and three-fourths. The upper surface is dull ferruginous or pale brown, shaded on the inner moiety with darker brown, and beautifully marked, lined, and spotted with black, forming a pattern more or less like that depicted in the illustration at a.

The caterpillar (*b*) is of cylindrical form, reddish or yellowish red in color, and marked with two brown lateral bands and a series of zigzag white interrupted lines upon the back. There are six rows of short, black, branching spines upon the body. The first thoracic segment bears a pair of these spines nearly twice as long as the remainder.

The chrysalis or pupa is nearly white in color, marked with dark brown and black spots, the dorsal surface being ornamented with golden tubercles arranged in rows. Altogether it is a most beautiful object. It is illustrated at *c*.

This species has a wide distribution, extending from Long Island and Connecticut southward, and westward from Virginia over practically the entire continent and into South America, where conditions favor its development.

It is recorded to feed upon the passion flower.

Oligia grata Hbn.—December 6, 1900, Mr. G. W. Morris, Poin-dexter, Va., wrote that this species of Noctuid was concerned in injury, with the spotted cutworm (*Noctua c-nigrum*), to violets grown in his vicinity. Both blooms and leaves of the plants were eaten.

The red-banded leaf-roller (*Lophoderus trifurcata* Walk.)—This species was reared from larvæ found feeding upon violets in the District of Columbia, August 13, 1897. It is a common species of the family Tortricidæ, and infests, besides numerous field and garden crops and fruit trees, rose, chrysanthemum, Lobelia, honeysuckle, and some other ornamental plants.

Unknown Tortricid.—November 7, 1898, we received injured specimens of a small Tortricid larva from Mr. H. B. Boone, Charlottesville, Va., with the statement that the species was troublesome to violets at that place. A remedy was requested to expel them from the beds in which they were lodged.

A leaf-miner on violets.—During September, 1885, a few larvæ of a leaf-miner were noticed on violets in Virginia near the District of Columbia. The larva was obviously coleopterous and evidently belonged to the family Chrysomelidæ, subfamily Halticini. It mined a large blotch on the upper side of the leaves. Unfortunately the species was not reared.

The yellow bear (*Spilosoma virginica* Fab.)—The yellow bear is of very common occurrence in greenhouses but fortunately for the florist it is more abundant in the field, orchard, garden, and vineyard, and as it does not appear to prefer any particular greenhouse plant, attack is usually so distributed that injury is not felt if careful watch be kept for the appearance of these larvæ so that they may be promptly destroyed.

June 27, 1900, Mr. Dorsett reported this species as occurring on violets in his greenhouse at Garrett Park, Md. A number of specimens were brought to the writer from which the moths began issuing

July 19. On the same date we obtained moths from larvæ received during June from Mr. J. H. Heard, Montreal, Ga., where they were found attacking cabbage. August 8 another lot of larvæ were received from Mr. Dorsett. It was also observed on two earlier occasions in July in 1898 and 1899.

Arctia natis Dru. (?)—Specimens of the larvæ of what were believed to belong to this Bombycid moth were received November 10, 1898, from Mrs. H. B. Boone, Charlottesville, Va., with report that they had been found in violet beds at that place.

Injury to violets by myriapods, sow-bugs, etc.—Different species of myriapods, or thousand-legged worms, and sow-bugs or wood-lice have been reported as occasioning injury to cultivated violets.

The myriapods are not positively known to be the cause of original damage to plant life, but it is not impossible that they assist in injury after the plant has become weakened by the attacks of true insects, such as cutworms and other caterpillars. Myriapods are scavengers by nature, and the product of damp and neglected soil containing an excess of decomposed vegetable matter or soil humus.

Two species have recently been identified in connection with injury to violets, and determined by Mr. O. F. Cook, of this department, as *Orthomorpha gracilis* (C. L.) Koch, a form found in troublesome numbers in and about the District of Columbia, and *Campodes flavicornis* (C. L.) Koch. The latter was reported January 14, 1901, by Mr. James K. Marks, jr., Arlington, Md., to be found in the ground about violet plants, which seem to die as soon as these thousand-legged worms congregate about them. It was stated that these creatures ate the small white roots of the plants.

In the American Florist for December 14, 1893 (Vol. IX, p. 448), the late Dr. C. V. Riley published a short letter in answer to correspondence concerning the occurrence of a myriapod identified as of the genus *Julus* said to be injuring violets, locality not stated.

A common species of sow-bug, *Armadillidium armadillo* Linn., occurring in the District of Columbia and vicinity, has been reported to do occasional damage to violets.

A species of sow-bug was received at this Department in 1890 from New Orleans, La., with the statement that it was destructive to the flowers of violets and pansies at that place and the present year. March 26, 1901, Miss N. L. Horlbeck reported injury to violets at Charleston, S. C.

Sow-bugs or pill-bugs, as they are also called, are not true insects, but crustaceans, but as they as well as the myriapods are classed by florists and the public generally with true insects, they may properly receive passing mention in this connection.

Injury by sow-bugs is apt to be exaggerated in many instances, still these creatures are often troublesome in greenhouses and in similar

locations. Ordinarily they can be kept in check by poisoned baits, the same as those used against cutworms, or still better by distributing about the places which they infest slices of potatoes or other vegetables that have been dipped in a solution of Paris green prepared at the rate of about 1 pound to 100 gallons or a little less of water.

Aphodius granarius Linn.—March 15, 1901, Mr. A. F. Woods showed the writer specimens of this common dung beetle with report that it occurred in great abundance in a violet house at Takoma Park, D. C. He stated that in a small corner of the house hundreds of thousands of the beetles could be seen crawling and tumbling over each other. So far as we know, this dung beetle agrees with others of its kind in being innoxious. There is, however, a recorded instance of reported injury, that by Prof. C. H. Fernald (Bul. 1, Hatch Experiment Station, Mass. Agric. College, p. 3). Specimens of the beetles were received from Lancaster, Mass., with the statement that they had been found destroying seed corn in the ground before it had sprouted. This is one of our commonest dung beetles, and its occurrence in the violet house was, of course, due to the presence of manure in which the species breeds. It has been surmised that from the known habit of this species feeding in part on fragments of undigested grain that it might, under favoring conditions, transfer its attentions to seed corn in the hill, but this seems somewhat doubtful.

ROSE BUD-WORMS AND LEAF-TYERS.

Among the many insect pests which the florist has to combat in the cultivation of roses grown under glass are several small species of bud-worms and leaf-tyers, the larvæ of moths of the family Tortricidæ. Of these some of the most important will be considered.

THE ROSE BUD-WORM.

(*Penthina nimbatana* Clem.)

RECENT INJURY.

During the past summer the attention of the writer was called to the work of the larva of *Penthina nimbatana* Clem. on hothouse roses through Messrs. Erwin F. Smith and P. H. Dorsett, of this Department. July 8 word was first received of injuries to roses in the green-houses belonging to Mr. Alexander Garden at Anacostia, D. C. The insect was in the larval condition when received, July 11, and remained so, feeding until July 13, when one or two showed signs of approaching transformation. The roses were being injured by the work of the larva on the foliage, buds, and flowers, the buds especially suffering.

Rose appears to be the only known food plant of this larva, and heretofore, it appears, it has never been recorded as attacking any portion

of the plant other than the leaves. In our Divisional notes, however, there is a record of the rearing of the moth, December 22, 1896, from larvæ found December 15 folding leaves and injuring buds of roses in a hothouse in the District.

PUBLISHED RECORDS.

The first record that the writer finds of the food habits of this species was published in 1881, a note by Mr. D. W. Coquillett of four lines, descriptive of the larva and its food plant, wild rose, *Rosa blanda* (Tenth Rept. State Entom. Ill., 1881, p. 153).

Mr. C. H. Fernald in his Catalogue of the Tortricidæ of North America, published in May of the following year (Trans. Amer. Ent. Soc., Vol. X, p. 31), mentions rose as a food plant. In the same year, 1882, Mr. Coquillett, in comparing the larva of this species with that of *Cacæcia rosaceana* Harr. (11th Rept. State Entom. of Ill., p. 12), states that they are utterly indistinguishable from each other in certain individuals, and makes the further remark that *nimbata* was reared by him only from *Rosa blanda*. "It binds three or more of the terminal leaflets together for a habitation, and there appears to be only one brood produced in one season."

The next year the same writer gives a brief description of the larva in *Papilio* (Vol. III, p. 101). Larvæ "were taken the first week in June; they pupated a few days later, and the imago issued June 20 and 21."

During the same year the late Dr. J. A. Lintner published a note on injuries by this species to rose plants in greenhouses (Count. Gent. Mar. 1, 1883, p. 169). This note was in response to inquiry from a correspondent, "D. J. G.," Scarsdale, Westchester County, N. Y., dated February 7 of that year.

In his Fourth Report as Entomologist of the State of New York (1888, pp. 213-215), Dr. Lintner gives a more extended account of this species, with illustrations of the moth.

DESCRIPTION AND DISTRIBUTION.

The parent insect is a small moth of the family Tortricidæ. It is shown in the accompanying illustration (fig. 23, *a*). The general color is brownish gray, the outer portion of the fore-wings and the under surface of the hind-wings being lightest. The inner portion of the fore-wings is dark brown in color, mottled with white, black, and light purple spots, the prevailing pattern being about as indicated in the figure. The wing expanse is about five-eighths of an inch (16^{mm}), and the length of the body is about half as long.

This species has a rather wide distribution, as the following list of localities, based for the most part on outdoor occurrences, shows:

Maine; Massachusetts; Albany, Scarsdale, and elsewhere in New York; Pennsylvania; District of Columbia; Woodstock and elsewhere in Illinois; Wisconsin.

THE LARVA AND PUPA.

The earliest stages of this species do not appear to have been studied. The full-grown larva is shown at *b* of figure 23. The head and cervical shield are shining dark blackish brown, verging to black in the outer portions, the three pairs of forelegs and two lateral marks on the first thoracic segment are dull black. The remainder of the body is rather bright, clear apple green in color, which means that the spiracles, except on the first thoracic segment, the piliferous warts, and the anal plate are all concolorous. The length of the mature larva when fully extended is a little less than five-eighths of an inch (14-15^{mm}).

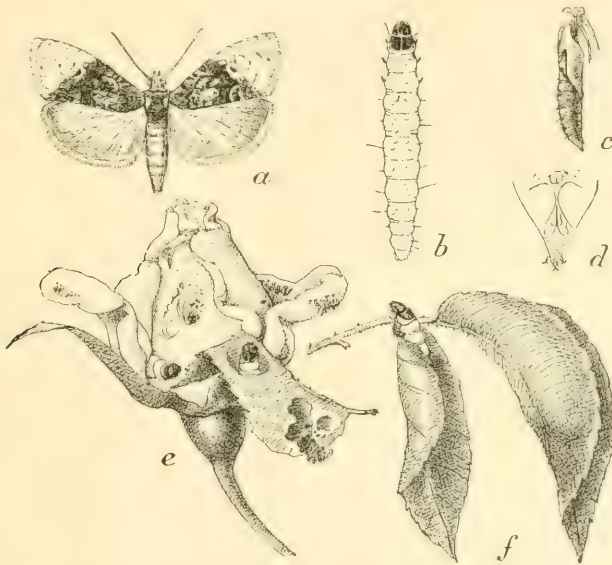


FIG. 23.—*Penthina nimbatana*—*a*, moth; *b*, larva; *c*, empty chrysalis skin; *d*, terminal segment of pupa; *e*, rosebud, showing larva at work; *f*, leaves folded by larvæ—all twice natural size, except *d*, which is greatly enlarged (original).

At *c* and *d* of the illustration the pupa is shown, *c* representing the empty chrysalis skin after the escape of the larva, and *d* showing the character of the anal segment. The length is nearly three-eighths of an inch (8^{mm}), and the color is light brown.

At *e* of the figure the manner of work of the larva on an unopened rosebud is illustrated, and at *f* two leaves are figured as folded by the larva. The leaves of the rose are joined together after the manner of the larvæ of this group of insects by silken threads and the larva lives within the case thus made, feeding upon the leaves of which it is composed, and later leaving it to attack others.

LIFE HISTORY.

The life economy of this rose pest has not been fully investigated. The parent moth, according to Lintner, who has observed the species

in New York State, and from whose writings (l. c.) the following account of the life history is in the main compiled, appears in ordinary seasons in the vicinity of Albany about the middle of April. Its eggs are laid at night and presumably on the terminal leaves of rose bushes when they are pushing out from the buds. The caterpillar or larva, after hatching, begins by binding together the margins or surfaces of a folded leaf. With an increase of size the leaf, partly eaten and opened out by its rapid growth, is abandoned for another, or the larva selects two contiguous leaves and fastens them together. This habitation in turn, with the more advanced growth of the creature, is deserted for still more ample quarters, which it finds among several of the terminal leaves or in the unopened buds, as has been shown by recent observation in the District of Columbia.

Larval growth is rapid and at each successive molt the papillæ or piliferous warts and the hairs proceeding from them become more conspicuous. By the end of May the larvæ have attained full maturity, cease feeding, and are then believed to drop to the ground to undergo their final transformations among the dead leaves. The reason for this belief is that the pupæ have never been found among the folded or fastened leaves on the rose bushes.

The period of pupation is about nine or ten days. The moth of the first generation has been observed abroad at Albany as early as June 2. Eggs are laid for a second generation and the new operations of the caterpillars are soon to be seen and are extended into July. Dr. Lintner expresses the opinion that there is possibly a second generation,¹ since the transformations among insects of this class are quite rapid and several generations are of common occurrence in many species. The latest date recorded near Albany was July 25.

The fact of our rearing this insect to the adult from larvæ taken in December would seem to indicate that there may be three, or perhaps even four, distinct generations developed each year, under glass at least, in a climate like that of the District of Columbia.

As the name of rose leaf-tyer is preoccupied by *Penthina cyanana*, which will presently receive mention, rose bud-worm is proposed as a suitable appellation for this insect.

A PARASITIC ENEMY.

One larva received from Anacostia was seen to be parasitized, the parasites being noticed in the larval condition from July 11 to 13. The adult parasites began to issue July 15 and were identified by Mr. Ashmead as *Eulophus cyriades* Walk., a Chalcidid fly.

¹ In speaking of the different generations, Lintner mentioned the first appearing moths as one brood, and the first generation hatched during a year (which the writer considers the first generation) as a second brood, and the second generation as the third brood.

REMEDIES.

This species is amenable to the same remedies as the greenhouse leaf-tyer, considered in the initial article of this bulletin.

The presence of the caterpillars on roses is so obvious as to be easily detected, and all that is necessary in many cases when they are found in the leaves is to crush them between the thumb and forefinger. If the greenhouse is not fumigated the only remedy after the caterpillars have attacked the buds is to cut off the buds and burn them, or destroy them by crushing under foot.

Owing to the concealed manner of life of the larva it is doubtful if insecticides would be of much value when the insect is found on roses in gardens, hence hand methods must be resorted to.

The larvæ of a number of other moths, mostly Tortricidæ, attack roses in much the same manner as the rose bud-worm. Some of the best known of these may be briefly mentioned.

THE ROSE LEAF-TYER.

(*Penthina cyanana* Murtf.)

A species closely related to *Penthina nimbata* is *P. cyanana*, which was described by Miss Murtfeldt in 1880 (Amer. Ent., Vol. III, pp. 14-15). The habits of this species do not appear to differ materially from those of *P. nimbata*. It is more abundant on roses growing in the open, but according to Mr. G. C. Davis it also attacks roses in greenhouses. Of its injuries at Kirkwood, Mo., Miss Murtfeldt wrote that it was occasionally so abundant as to devour or mar fully 20 per cent of the rosebuds, especially of white or light-colored varieties.

Among the notebook records of the Division of Entomology this is stated to have been found by the late Dr. Riley in injurious numbers on his roses at Washington during the summer of 1879. July 6 of the next year he received rosebuds containing larvæ, which were reared to the adult, from Mr. Henry Plumb, Pleasanton, Kans.

This species was found at work on roses at Alexandria, Va., by Mr. T. A. Keleher, of this office, in July, the imago issuing in the middle of that month.

The recorded distribution of this species comprises portions of the states of Missouri, Kansas, Pennsylvania, and Michigan, and to this list may be added the District of Columbia.

As in manner of life all these rose pests are similar, the remedies to be applied are the same.

THE OBLIQUE-BANDED LEAF-ROLLER.

(*Cacaccia rosaceana* Harr.)

One of the most important of the leaf-rollers, from the economic point of view, if we consider its injuries to all its food plants, is

Cacaccia rosaceana. This is a well-known enemy of all sorts of fruit crops of the family Rosaceae, as well as of several other orders, and is treated in most popular works on agricultural entomology.

Specimens of pupæ and adults of this species were received from Mr. S. S. Wilson, Libonia, Pa., with the statement made in an accompanying letter dated May 3, 1898, that it was received by him in a shipment of roses from a firm in Ohio, and that, on examining the roses, larvæ and chrysalides were found, and many of the leaves of the plants were eaten away.

THE ROSE LEAF-FOLDER.

(*Cacaccia rosana* Linn.)

This is an introduced species which attacks roses, but is not, so far as the writer is aware, particularly troublesome, at least in greenhouses. It is very likely to become injurious, however, at any time. It is figured and described as an enemy of currants by Messrs. Comstock and Slingerland (Bul. XXIII, Cornell Univ. Expt. Sta., pp. 119-121), and has been stated by Dr. Luggert to attack also the apple, wild rose, raspberry, hazel, hawthorn, and gooseberry (Fourth Annu. Rept. Entom. State Expt. Sta. Univ. Minn., 1899, p. 228).

OTHER LEAF-ROLLERS.

A short notice of injuries by the fruit-tree leaf-roller, *Cacaccia argyrosphila* Walk., to the buds of roses in greenhouses was published in Insect Life (Vol. III, p. 19).

To this list must still be added, as species that are known to attack roses, and are hence likely at any time to invade the greenhouse and assume the bud-destroying habit, several other Tortricids, among which may be mentioned the grape-berry moth, *Eudemis botrana* Schiff., *Platynota flavedana* Clem., *Tortrix albicomana* Clem., *Cenopsis pettitanæ* Rob., and *reticulatana* Clem., as also *Lophoderus trifera* Walk., elsewhere noted as a violet insect.

FULLER'S ROSE BEETLE.

(*Aranigus fulleri* Horn.)

Various greenhouse plants, and roses in particular, are often severely injured and destroyed, unless remedial measures are adopted, by a moderate-sized, obscure, brown or gray snout-beetle, commonly known as Fuller's rose beetle, *Aranigus fulleri* Horn. Prior to the year 1874 this species does not appear to have been recognized; in short, its technical description was not published until the Centennial year. At about that time and soon afterwards, as well as at intervals later, it has attracted considerable attention on account of its ravages

on roses, camellias, geraniums, and other ornamental plants in different portions of the country, particularly in the Eastern States, and more especially in New Jersey, New York, and Massachusetts. During the last two years this species has been troublesome to roses and carnations, especially in portions of New York and Wisconsin, and in lemon groves in California as well as in Hawaii.

This insect is destructive in both of its active stages, doing most damage as a larva, when it lives in the soil and feeds upon the roots of its food plants, the beetle practically confining itself to the foliage, flowers, and buds of the plants which it attacks. Although preeminently a greenhouse pest in California, particularly in the southern portion, groves of orange and lemon as well as other trees sometimes suffer much injury.

DESCRIPTIVE.

The beetle.—The adult of this insect is one of the so-called scarred snout-beetles (of the family Otiiorhynchidae), and was given its specific name in honor of the late A. S. Fuller. It measures from a quarter to nearly three-eighths of an inch in length, and is of the form shown in figure 24 at *c* and *d*. The snout is quite short and scarred at the sides of the mandibles. The head is white, and the abdomen is ovoid. The color is dark dirty brown, and the entire body, including the legs, is lightly covered with gray or pale-brown scales. On each side of the elytra there is a whitish diagonal line.

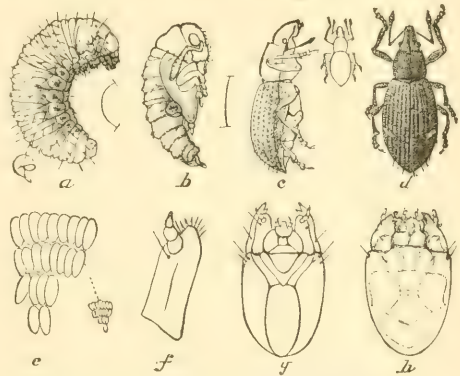


FIG. 24.—*Aramigus fulleri*: *a*, larva; *b*, pupa; *c*, beetle, outline side view; *d*, same, dorsal view, the outline between them showing natural size; *e*, eggs enlarged and natural size; *f*, left maxilla with palpus; *g*, lower side of head of larva; *h*, upper side of same enlarged (from Riley).

The egg.—An egg mass is shown in the illustration at *e*, greatly enlarged, the natural size being indicated at the right side. An individual egg measures about 0.9^{mm} in length and about one-quarter that in width. It is smooth, soft, and of a pale translucent yellow. The normal form is ellipsoidal, but great variability occurs from the close compression of the eggs, as they are deposited in rows.

The larva is shown in the illustration at *a*. It measures about 8^{mm} in length, is milky white in color; is destitute of organs of locomotion, and when in resting position is arched usually about as shown.

At *f* the left maxilla of the larva with its palpus is shown; *g* illustrates the under side of the head, and *h* represents the upper side, these last three figures being much magnified.

The pupa is about 7^{mm} in length, and of the same milky white color as the larva. It is shown, side view, in the illustration at *b*.

DISTRIBUTION.

At the time this species was described in 1876 (Rhynchophora of America North of Mexico, pp. 94, 95) it was known to have a wide distribution, stated to be "from New Jersey to Montana." At the present time it is known to occur from Maine to California, and has been reported at various times as being destructive in greenhouses in a large number of states. The habit it has of feeding in the larval state in the earth about greenhouse plants makes it peculiarly susceptible to transportation with the plants from one locality to another, and it is quite remarkable that it does not cause more destruction than is reported.

The first observed specimen of this insect appears to have been received by Mr. A. S. Fuller from Montana, and as the only other species of the genus *Aramigus* is American, it seems probable that, in spite of the fact that the insect lives almost exclusively indoors, it is native to America, although probably of neotropical origin. It was probably introduced from Mexico.

A list of localities follows: Bucksport, Me.; Cambridge, Boston, Worcester, Mass.; New York, Rochester, Little Falls, Poughkeepsie, Albany, Long Island, N. Y.; Madison, Summit, Jersey City, Union County, N. J.; Baraboo, Wis.; Mt. Airy, Griffin, Ga.; Sandwich, Ill.; Montana: National City, San Francisco, San Diego, Los Angeles, Fullerton, Cal.; Brantford, Stewarton, Ottawa, Canada, and Hawaii.

Concerning the distribution and periodicity of attack of this species, Mr. Schwarz of this office has pointed out (Proc. Ent. Soc. Washington, Vol. III, p. 145) that the insect does not occur so far as we know out of doors, either in Montana or in neighboring states farther south, although it is known to live outdoors in California.

If it could be proved that it lived in Montana originally, we have a case of rapid diffusion eastward analogous to that of the Colorado potato beetle, the weevil having spread to the Eastern States only a few years after that Chrysomelid. There is this difference, however, that the latter became disseminated mainly by flight, and the former, a wingless insect, through the agency of man.

RECENT INJURY.

March 15, 1900, Mr. Willie A. Toole, Baraboo, Wis., sent specimens of the larva of this beetle with the information that the insect was very troublesome in greenhouses around the roots of rose-scented geranium. They first eat the fine roots and then the larger ones, and when they get through with the plant there is nothing left of the roots

but a few stubs. They appeared to prefer geranium to any other plant growing in houses there, and they always came under observation in winter. The species was kept in check to a considerable extent by turning the plants out of their pots and picking out such grubs as could be seen and killing them, and by digging up and picking out the grubs from the dirt in the benches.

Mr. C. L. Marlatt of this office informed the writer that this species caused injury in lemon groves near San Diego, Cal., during July, 1900, and that in that portion of the country it is known as an occasional pest, having been established there for a number of years.

A similar report of injury in the same locality was received from Mr. G. P. Hall, April 19, 1899.

OCCURRENCE IN THE HAWAIIAN ISLANDS.

During February, 1901, we received specimens of this species from Mr. Albert Koebele, at present stationed at Honolulu, H. I., with notes upon its habits. These specimens have been compared with authentically determined *Aramigus fulleri* by the writer, as well as by Mr. Schwarz and Mr. Charles Fuchs, and there is no doubt of their identity. It seems that the species is known in Hawaii as the Olinda bug, and has been described by Mr. V. R. Perkins as *Pandamorus olinda*. Some notes are furnished by Mr. Koebele, which bear upon the insect's life economy. Its presence has been frequently noticed upon trees as well as upon Hilo grass. Many trees of Java plum recently planted have been seen by Mr. Koebele with every leaf eaten off, and some have died from the effects of the beetle and Hilo grass combined. The insect appears to be most numerous along the border of forests, and is found from the seashore as high up as 5,000 feet elevation. Seven years prior to the date of writing the beetle was seen from Paia, where it was destructive to roses and garden plants generally. Our correspondent believes that it must have been present on the islands long before it became prominent as a pest, and he as well as Mr. Schwarz, the writer, and some others are inclined to the belief that it is an introduction from Mexico—Mr. Koebele believes probably from Acapulco, but does not state reasons.

Larvæ have been found under stones, and in large numbers also in galls produced by Tortricidæ.

HISTORY AND LITERATURE OF THE SPECIES.

Fuller's rose beetle appears to have been first brought to notice as a pest in the year 1879, when Peter Henderson published a four-column illustrated article concerning it in the "Gardeners' Monthly" for March of that year (pp. 86, 87).

This species furnishes an interesting example, analogous to that of the so-called black aphid of the violet, of how long an insect can do

extensive damage before public attention is drawn to its ravages or even to its identification. In Mr. Henderson's article he states that by correspondence with rose growers in six different states, and from personal observations, he had been forced to the conclusion that, in a large majority of cases where cultivation of roses during the winter proved unprofitable, the trouble was traceable alone to the ravages of this rose beetle. Owing to the small size and inconspicuous appearance of the beetle, and its habit of shunning the daylight and concealing itself under the leaves, as well as to the subterranean habits of its larva, its presence is not apt to be noticed by any except the most observing, or by persons who have had experience with it. The account in question includes, besides mention of injury by this species at Madison and elsewhere in New Jersey in the vicinity of New York City, a letter from Dr. Riley giving in condensed form what was known at that time concerning the insect's history, classification, distribution, and biology.

This article was followed by a more extensive one by Dr. Riley in the same publication for October (pp. 310, 311), republished from the *Scientific American* of August 30, 1879 (p. 129), these last two accounts including the illustration used in the present article. All of this matter was brought together in Dr. Riley's report as Entomologist for the Department of Agriculture for 1878 (Nov., 1879, pp. 255-257), technical descriptions of the immature stages being added. Injury at that time was most noticeable to roses and camellias. In the Report of this Department for the following year (pp. 250, 251) Professor Comstock furnished a few notes on the destructive occurrence of this insect at San Diego, Cal., in 1879, adding some unrecorded food plants and making mention of a wireworm found preying upon the larvæ.

An interval of four years elapsed before injury by this species was again noticed, at least so far as published records go. In November, 1883, we received complaint from Worcester, Mass., of injury to *Azalea* and *Cissus* (Report Dept. Agric. 1884, p. 414).

In December, 1884, injury was complained of to Dr. Lintner by extensive rose growers at Poughkeepsie (2d Report State Entom. N. Y., 1885, pp. 142-144). Dr. Lintner states that this species was first brought to his notice in 1874 because of injury to camellias and other foliage in conservatories at Albany, N. Y. The same writer had an article in the *Country Gentleman* of February 3, 1887, based upon injuries of this rose beetle at Bucksport, Me. *

In 1889 Mr. Coquillett reported this species to be injurious in Los Angeles County, Cal., where it was mistaken for the plum cureulio. It was very destructive at that time to the foliage of oak, camellias, palms (*Washingtonia filifera*), *Canna indica*, and several other plants.

The following year a short account of this species and its occurrence in California was given in the Annual Report of the State Board of

Horticulture of California for 1889 (1890, pp. 227, 228). An account by Dr. James Fletcher, in his report as entomologist and botanist of the Dominion of Canada, 1889 (1890, pp. 88-90), appeared at about the same time. Injury was noted at Stewarton and Ottawa, Canada, roses having been much injured. Begonias and lilies were also attacked. Dr. Fletcher also published an account, with original illustrations, in the report of the Entomological Society of Ontario for 1890 (1891, pp. 62-64).

In the year 1894 Mr. John G. Jack (Trans. Mass. Horticultural Soc. for 1894, p. 147) mentioned this species in connection with injury to primroses in the vicinity of Boston, Mass.

Brief mention of injury to carnations is given by Mr. F. A. Sirrine in the American Florist for March 3, 1900 (p. 913). Damage was noticed at Little Falls, N. Y., in October of 1899, and followed the removal of roses from the greenhouse in which the carnations grew.

There are several other notices of this species in addition to those which have been mentioned, but a few of these are not accessible, and others add little to our knowledge of the insect or its habits.

DIVISIONAL RECORDS.

Of reports of injuries other than those that have been already cited, the following are on record in the office, each communication which will be mentioned having been accompanied by specimens:

December 5, 1879, information was received from Mr. E. J. Wickson, San Francisco, Cal., of injuries by this species in orchards and gardens.

November 30, 1883, Dr. C. W. Minot, Worcester, Mass., wrote that this insect was found in greenhouses, and that its favorite food plant was Azalea; but *Cissus* and "inch plant" were also attacked. It was noticed by our correspondent that the beetles were to be found during the middle of the day perched as high as possible on the plants which they infest, and that they seek concealment upon the slightest disturbance. They fed upon the new shoots and tender leaves, and when a plant was permitted to stand alone they would frequently trim off the new shoots as fast as these appeared. The beetles disappeared about the first of January, a new brood replacing them in the spring.

December 31, 1889, Mr. A. W. Orr, Sandwich, Ill., wrote that the beetles were doing great havoc in greenhouses; they were described as gorging themselves and then crawling to the axils of the leaves or branches.

June 13, 1890, Mr. J. N. Harris, Griffin, Ga., stated that the beetles ate rose leaves and those of cape jessamine, stripping the bushes in a short time.

September 26, 1892, Messrs. George R. Hinde & Co. wrote that this species was becoming a pest at Fullerton, Orange County, Cal., by

eating the foliage of young nursery trees of the citrus group; the beetles were found on apricot, pear, and other trees, and attack on persimmon was noticed. Our correspondents observed that the beetles concealed themselves behind or between the leaves, or in other retired places, and when disturbed suddenly dropped to the ground and feigned death to escape observation, which they were easily able to do, owing to their color bearing so close a resemblance to the dry soil.

September 10, 1896, a communication was received from Mr. David A. Horton, National City, Cal., that the insect was depredating on orange in that vicinity.

SUMMARY OF FOOD AND OTHER HABITS.

In addition to roses this species, as has been previously related in treating of its recorded history, feeds upon geranium, Hibiscus, Dracæna, orange, lemon, cape jessamine (Gardenia), Java plum, Achyranthes, Abutilon, Plumbago, Azalea, "Cissus," "inch-plant," carnations, Begonias, lilies, primrose, Hilo grass, oak, camellia, palms, and canna. Tea roses appear to be particularly susceptible to attack, and geranium seems to be preferred next after roses. The beetles are of nocturnal habit, feeding so far as known only after dusk. During the day they are generally quiet, resting in more or less concealment under or among the leaves of their food plants or clinging to the twigs or smaller branches in such positions as not to be readily observed. They are quite active at night and feed voraciously. When disturbed they "play possum," after the manner of many other Coleoptera, and particularly beetles of the same family, by dropping to the ground and drawing their legs and antennæ tightly to their bodies. As they often remain motionless for a considerable time and as their color is so very similar to that of the earth about their food plants they readily escape notice. They feed principally upon the leaves, but their greatest injury is accomplished by severing the leaves more than by the quantity of foliage consumed.

The life history of the insect as worked out at this office several years ago is approximately as follows:

The eggs are deposited in flattened batches consisting of several contiguous rows, each batch containing from ten to sixty eggs. The female, as in another species of the same family, which has been treated in earlier bulletins (see account of *Epicerus imbricatus* in Bulletin 19, pp. 62-67), has the habit of secreting her eggs by thrusting them between the loose bark and the stem, especially at the base just above the ground. In upward of twenty batches examined the eggs were found to have been thus concealed, either between the loose bark, as described, or in some similar crevice. More rarely they are deposited upon the ground between the earth and the main stem of

the plant, and the eggs adhere so firmly together, and to the place of deposit, that they are not so easily seen and are also with extreme difficulty detached. The eggs observed required about a month to hatch.

The newly hatched larva, which is pale yellowish in color with light brown mouth-parts, is quite active, and upon hatching burrows immediately into the ground, where it soon acquires a bluish hue.

The larval period does not appear to have been ascertained, but it is with little doubt at least one month, and perhaps two or three more, this stage being passed entirely in the ground, where the pupa state is also assumed. As this species lives by preference, at least in most of the United States, under glass, there can be no great regularity in the duration of the periods of transformation. The insect may, in fact, be found in all stages during the winter and early spring months, injury appearing to be most noticeable in December.

NATURAL ENEMIES.

A single carnivorous insect appears to have been recorded as preying upon the larvæ of this beetle, this observation having been made in the rearing cages at this Department in 1878. The insect was a wireworm, the larva of a click-beetle, and was somewhat doubtfully referred to *Drasterius amabilis* Lec.

Toads are frequently found in greenhouses, and sometimes are purposely put in such places to prey upon destructive insects. They are known to feed upon insects related to this rose beetle, and probably feed upon the species in question.

Natural enemies that have been observed by Mr. Koebele in Hawaii include the mina bird and mongoose.

METHODS OF CONTROL.

The beetles are so long-lived and hardy that it is difficult, if not impossible, to destroy them by the use of ordinary insecticides, even hydrocyanic-acid gas being practically powerless against them used at a strength that would not kill the plants affected. The remedy which has found most favor is to search for and destroy the beetles, and a good time for this work is during the months of November and December, when the beetles may often be found congregated upon the plants. By persistently following this method the insect has been practically exterminated in many greenhouses which it formerly infested. By killing the beetles the number of larvæ will of course be lessened. Plants showing severe injury should be pulled out and the soil about them searched for the larvæ; or the larvæ may be killed by means of the bisulphide of carbon applied to the soil about the roots of the affected plants. It should be inserted by means of a metal syringe, a few drops here and there about the roots being sufficient to destroy the

insects. Kerosene emulsion applied in a similar manner and in larger quantity will also kill larvæ, and the use of tobacco waste in liberal quantities about the roots of the plants is advisable, as it acts both as an insecticide and a fertilizer.

We may also take advantage of the wingless condition of this beetle by surrounding the trunks of rose bushes and of the different species of ornamental plants attacked by it with cotton bands, such as are in use against canker-worms and similar species. The bands should be applied before the beetles have found their way to the plants or after jarring the beetles from them.

A CALIFORNIA FLOWER BEETLE INJURIOUS TO ROSES.

During the past summer a species of flower beetle, known as *Hoplia callipyge* Lec., and native to California has been observed by Mr. Schwarz to be very destructive to roses at Fresno, Cal., and vicinity. From that gentleman we have also received specimens of the work of the insect, which show that it is capable of quite serious injury to flowers, but is hardly such a pest as the rose-chaffer, *Macrodactylus subspinosus*, of the East. It is quite probable since injury by this species of *Hoplia* to roses has not been given much attention by entomologists in available early reports and bulletins, that injury was not noticed until recently but is on the increase, and will probably continue to multiply and spread, since most insects which feed upon wild roses, when they acquire a taste for cultivated ones, prefer the latter.

This species was recorded in volume V of *Insect Life* (p. 343) to be doing much damage to the young fruit buds and blossoms of the Muscat grape in vineyards in Fresno County, Cal. The insect was recognized as a yearly visitor, appearing in spring, and up to the time of writing, May 17, 1893, was known only as an enemy of rose leaves, doing much damage to the young buds. The beetles were said to be very numerous, in some vineyards as many as hundreds to a single vine; in one case about three acres were completely stripped of buds. The beetles were also present on rosebushes about dwellings.

A second correspondent in the same county wrote of similar injury to roses and to grapes at about the same time, a fact which has been briefly mentioned on page 386 of volume VII of the same publication.

This *Hoplia* is one of twelve described species, all of similar size, resembling each other more or less closely. They are oblong flattened beetles, with the body more or less completely covered with flat scales.

H. callipyge (figure 25) belongs to a group in which the posterior claws are not cleft, and in which the anterior angles of the thorax are obtuse, and the hairs are long on the thorax, elytra, and pygidium. It is rather dark brown above and incompletely covered with much lighter grayish brown scales on the elytra. The under surface and pygidium

are densely coated with small, pale grayish, brilliantly iridescent scales. The legs are reddish and sparsely covered on the femora with similar scales.

The length is a little less than three-sixteenths of an inch (7.9^{mm}).

The males, as frequently happens in this genus, differ from the females considerably in appearance. They are usually smaller and so much darker as to look like distinct species. The color of the male is quite dark brown, and the scales are less evident than in the female.

This species appears to be restricted to California, and to be most abundant in the southern portion of that State. The list of localities from which we have received this species or reports of its occurrence includes Los Angeles, Selma, Placer County, Fresno, Kern County, Lake Tahoe, and Sacramento.

Some interesting observations upon this species were made by Mr. Schwarz, who communicated a portion of them to the writer. It appears from his statement that roses are most badly injured, from half a dozen to a hundred individuals occurring on a single flower. The insect is rather generally known in California as rose bug, and even as the rose-chaffer, being mistaken by some for the Eastern rose-feeding *Macrodactylus*. A singular and unaccountable fact is that the beetles are very strongly attracted to white and other light-colored roses, such as yellow and pink ones, and to light reds, but the dark reds, are, according to observation, entirely exempt from attack. The beetles bore into and through the roses, completely destroying them. The flowers of the Calla lily are always destroyed, the beetles occurring on them by hundreds. It seems that there is something about this plant—whether the petals or the long yellow spadix—that is poisonous to the beetles, and they die and collect with other insects in decaying masses in the deep calyx of these flowers. Whether or not in this condition they furnish nourishment for the plant remains to be ascertained. The flowers of magnolia, olive, and of various native plants, of which there are not many in the grape-growing regions, are also attacked, the list including late-blooming willows, lupines, and *Eschscholtzias*. As a rule, this species of *Hoplia* occurs too late, at least in the neighborhood of Fresno, to do much injury to the flowers of grape, and the same is true of orange. In fact, on the latter plant, it is possible that the beetles are of some benefit in reducing the surplus of blooms and thus improving the fruiting. Figs, it might be mentioned, because they have no flowers are exempt from attack.



FIG. 25.—*Hoplia callipyge*: female—four times natural-size (original).

No damage by this species in the larval stage has been observed, and it seems probable that although the insects may attack the roots and rootlets of growing vegetation, that they subsist mainly upon that which is dying or decayed, and, to a certain extent, also upon soil humus, which contains an excess of decomposing vegetable matter. In this respect it is probable that it resembles the habits of our Eastern rose-chaffer, *Macrodactylus subspinosus*, although the habits of this latter are not perfectly known. Mr. Schwarz observed that in spite of the frequent plowing to which the ground is subjected about Fresno, that it has little effect upon the emergence of the beetles, presumably because they pass through their transformations so deeply in the soil that the plow does not reach them. Where the ground is not plowed it may often be found fairly honeycombed where the beetles have made their exit. The beetles have been observed to crawl back into these holes, presumably for oviposition, and this seems to be a natural habit. Unfortunately, the pressure of other work at the time these observations were made prevented Mr. Schwarz from continuing his investigations.

REMEDIES.

Until we learn more of the life history of this species we can only suggest observations of the same line of remedial and preventive treatment prescribed in the case of the rose-chaffer in Circular No. 11, second series, of this office.

THE ROSE CURCULIO.

(*Rhynchites bicolor* Fab.)

May 16, 1900, Mr. Thomas Redmayne, Washington, Nevada County, Cal., wrote of the depredations of this species, specimens of which he sent. He stated that the curculio appears about the middle of May, or as soon as warm weather sets in, and confines its injuries to rose bushes, puncturing the flower buds; and that, even when occurring in small numbers, these beetles are able to destroy an entire crop of flowers in a small garden, as in fact they had done for the last two years on our correspondent's place. When cool weather sets in, about September, they disappear.

Hand-picking was resorted to, but without avail, for no matter if every beetle seen was destroyed about the same number could be found next day.

It was noticed that the beetles had the habit, in common with many other curculios, of dropping to the ground when disturbed, and they were captured by placing a hand under them very cautiously and catching them as they dropped.

The species was first noticed in that section about five years previous to the date of writing, no one having seen them earlier. The insect was known by the name of the rose curculio.

This curculio has been known for some time to live upon wild roses, and as early as 1889 was stated to feed upon both rose and raspberry (James Cassidy, Bul. 6, Colo. State Agl. College Exp. Station, p. 18).

June 2, 1891, Mr. Arthur Boyle, Santa Fe, N. Mex., sent specimens of this beetle with report that it was proving very injurious to roses in that vicinity, where it had not been known as a pest before. The beetles were stated to be frequently caught with their long snouts buried deep in the rosebuds, and they seemed also to cut the stem or otherwise injure the bud at the thin portion of the stalk below the calyx. The bud afterwards dropped and died (Insect Life, Vol. IV, p. 137). In volume VII of the same publication (p. 211) this species is stated by Prof. T. D. A. Cockerell to be very troublesome at Santa Fe, N. Mex., by eating holes into buds and bud-stalks of roses, as well as the expanded petals.

July 30, 1897, we received specimens from Dr. E. V. Wilcox with the statement that the beetles bore holes into rosebuds and are much complained of at Bozeman and Missoula, Mont.

This species is also stated to be very common and destructive to roses in Minnesota, destroying both flower-buds and flowers and depositing eggs in the fruit in which the young mature (Lugger, 5th Annual Report Entom. of Minn. for 1899, p. 180).

In the report of Mr. Alexander Craw as Quarantine Officer and Entomologist to the State Board of Horticulture of California for 1893-'94 (p. 86), mention is made of this species, with the statement that it is frequently found on ripe blackberries and raspberries, puncturing the fruit with its beak and causing it to decay.

The rose curculio is one of the Rhynchophora typical of the family Rhynchitidae, and may readily be known by its red thorax and elytra and black ventral surface, snout, and legs. In eastern specimens the colors are as indicated, but westward, in Colorado, specimens are found in which the greater part of the head is red, including most of the antennae and the legs. The form of the insect is well illustrated at figure 26. The rostrum, or snout, it will be noticed, is very long — nearly a third the length of the entire body, and the antennae are slender, with a well-marked three-jointed club. The length, exclusive of the snout, is a little less than a fourth of an inch (5—6 mm.).

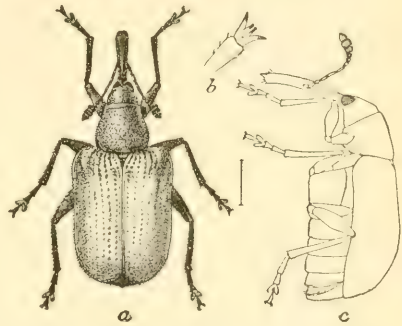


FIG. 26.—*Rhynchites bicolor*: a, female beetle; b, claw; c, female in outline from side; a, c, enlarged; b, more enlarged (original).

This species is well distributed from the Atlantic to the Pacific, and is found more abundantly northward. A list of localities in which it is known, verified in great part by specimens in the National Museum, includes the following: Buffalo, Ithaca, and New York, N. Y.; New Jersey, "common throughout the State" (Smith); Pittsburg and vicinity, Pa.; Washington, D. C.; Tennessee; Missouri; Minnesota; Wisconsin; Iowa City, Iowa; Cheyenne, and National Park, Wyo.; University, N. Dak.; American Fork Canon, and City Canon, Utah; Santa Fe, N. Mex.; Pocatello, Idaho; Montana; eastern Washington; Oregon; San Francisco, San Mateo, San Diego, Los Angeles, Los Gatos, and San Jose, Cal.; Hamilton, Ontario, Can.; Moosejaw, Assa, N. W. T.; Victoria, Vancouver' Island, North Bend, and New Westminster, British Columbia.

Hand-picking and jarring the beetles from the infested plants is all that is necessary in ordinary cases of attack. When the insects occur on other plants than canes bearing berries, or on roses soon to be picked, they can be destroyed in the usual manner by spraying with Paris green at the rate of about a pound to 150 gallons of water.

MISCELLANEOUS INSECTS INJURIOUS TO ROSES.

Roses have been quite subject to insect injury during the last few years, and some of the species which have been particularly destructive or troublesome are worthy of special mention. The rose aphides of the two commoner species have been abundant, and some complaint has been made of the rose-chaffer.

Short notes on some interesting instances of attack follow.

The bristly rose worm (*Cladius pectinicornis* Fourcr.)—Numerous complaints of injury reached this office throughout the month of June and the early portion of July, 1900, from residents of the District of Columbia. In most instances the larvæ were seen and all proved to be this insect. Injury was also noticed by the writer generally throughout the District wherever roses were grown and in neighboring portions of Maryland. In fact the species was more troublesome this year than ever before. Mrs. Flora W. Patterson, Assistant Pathologist of this Department, who furnished larvæ for identification, stated that the roses most affected were La France, General Jacqueminot, a few pink varieties hardy to the District, and some red roses recently imported from Holland.

It was noticed on June 27 that larvæ had attained full growth and were rapidly disappearing from the plants.

A rose beetle, *Trichius piger* Fab. An individual of this species which is illustrated by figure 27, was sent to this office June 27, 1900, by Mr. Ernest G. Asmus, a rose grower at West Hoboken, N. J., who reported that it was doing much injury to greenhouse roses, and espe-

cially to the variety known as the Bride. The beetles burrow into the center of the roses, destroy the flowers completely, and also eat the foliage.

Some interesting observations have been made concerning the habit of this ubiquitous flower beetle by Mr. James G. Needham (Amer. Nat., Vol. XXXIV, p. 365). He observed it in the flowers of *Iris versicolor* in New York State. The channeled sepals seeming to offer a favorite place for an afternoon nap, several beetles were found undoubtedly asleep. After repeatedly tickling two of a beetle's feet, it stretched itself like a lazy boy awakening. Although the beetle is not ill adapted by its size for visiting these flowers, it does not seem to pass from flower to flower, and therefore is not an important agent in pollen distribution. Upon reaching an Iris flower it is seemingly habitually deceived as to the point of entrance and endeavors for some time to effect ingress at its center between the branches of the cleft style. After clambering in and out of the central cleft repeatedly the proper entrance is at length stumbled upon. The stupidity of the species is summed up in the statement that if the beetle were seeking pollen it might, had it wit enough, obtain plenty of it by entering the other side up.

The oak pruner (Elaphidion villosum Fab.).—November 8, 1900, we received from Mr. F. A. Marlatt, from Manhattan, Kans., a package of stems of roses, evidently sweet-brier rose (*Rosa rubiginosa*), that had been amputated by this species, some of the larvæ being present in the infested twigs. The oak pruner has been treated somewhat at length in Bulletin No. 18 of the present series (pp. 35–40).

The tobacco bud-worm (Heliothis [Chloridia] rhesiae S. & A.).—August 4, 1900, the writer observed larvæ of this species feeding upon cultivated roses at Marshall Hall, Md. Larvæ entered the earth on the 13th and 14th, and the first moth appeared August 25, twelve days later. This species was described by Smith and Abbot in 1797 (Nat. Hist. Lep. Ins. Georgia, Vol. II, p. 199) under the name of *Phalœna rhesiae*, the specific name having been given it on account of one of its food plants, *Rhexia virginica*. Even at that early date the larva was known to attack tobacco, and was, in fact, called the "tobacco-bud-worm" by the authors mentioned. It was said to attack the bud and blossom, and to be "very pernicious in Virginia and other places, as it destroys the main shoot." Colored figures are given of the moth, larva, and pupa.

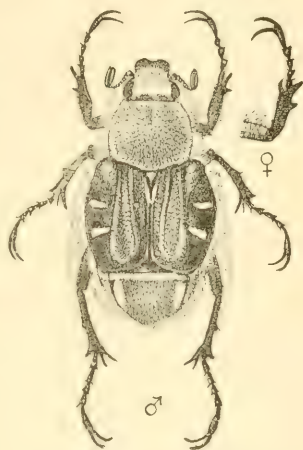


FIG. 27.—*Trichius piger*: male beetle, with female foreleg at right enlarged (original).

A short popular account of this insect, with figure, is given on pages 14 and 15 of Farmers' Bulletin No. 120.

THE MORNING-GLORY LEAF-CUTTER.

(*Loxostege obliteralis* Walk.)

Few of our ornamental garden plants suffer so universally from the attacks of insects as does the morning-glory (*Ipomoea purpurea* et al.). The more common forms of injury are shown on the leaves in the shape of numerous more or less rounded holes, the work of various species of tortoise beetles (particular species of *Coptocycla*), and on the edges of the leaves, where little semicircular or semioblong oval pieces are cut out by leaf-cutting bees (*Megachile* spp.). Another form of attack is that which will presently be described, the work of the larva of *Loxostege obliteralis* Walk. (*Phlyctanodes obliteralis* of Hampson's Revision), no account of which appears to have been hitherto published.

During the years 1898 and 1899 Messrs. T. A. Keleher and W. S. Canatsey, of this office, reported injury to cultivated morning-glory in the District of Columbia, and the former gentleman, who devoted considerable time to the gathering of larvæ in different localities, reported injury also to spearmint and plum. The material secured, together with observations which were conducted in previous years by Mr. Theo. Pergande, also of this office, and other information obtained by correspondence with Prof. E. E. Bogue, makes it possible to give a fairly complete account of the insect's life history and habits.

The larva is remarkable not only on account of its great beauty but also from its curious and evidently characteristic habit of gnawing the petioles or leafstalks on the upper side near the leaf in such a manner that only a small portion of the skin and fiber on the under side remains. The leaf hangs downward and gradually wilts and becomes dry, the larva apparently preferring drying leaves as food to fresh ones. The larvæ secrete themselves in the wilting leaves either by drawing together or folding over small leaves, or rolling over the edges of larger ones. In the shelter thus formed they remain during the day, coming forth to feed toward dusk.

When the larvæ appear in any abundance their work is quite apparent, the vines appearing very unsightly where the leaves, partially cut off, die and turn brown. They cut large holes in the leaves, which sometimes present the appearance shown in the illustration at *f*.

DESCRIPTIVE.

The egg.—The egg resembles that of *Phlyctania rubigalis*, previously described in this bulletin. It is scale-like, clear, grayish white when first deposited, so nearly translucent and so flat as to show

through it the green of the leaf upon which it is deposited. It is shining, glassy, iridescent, the surface finely granulated and rugose. The outline is tolerably variable—a broad oval, nearly round. The length is about 0.7^{mm} and the width 0.6^{mm} .

The eggs are deposited in rather regular overlapping masses of from three to twenty, a portion of a mass often showing a hexagonal arrangement inclosing one egg. The favorite place of oviposition is on the lower surface of a leaf.

The larva.—The larva when first hatched is clear, grayish white in color, and the markings of maturity show but faintly, being few in number, totally unlike those of the full-grown individual. After feeding, the green of the leaf shows plainly through the outer integument. A half-grown larva is shown in the illustration at *b*.

The moth.—This species is a member of the superfamily Pyralidina, family Pyraustidae, and has recently been placed in the genus *Phycetanodes* *Guen.* (Hampson, Pr. Zool. Soc. Lond., 1899, p. 208) though still catalogued under *Loxostege* in our latest list (Smith's List Lepid. Boreal Amer., 1891). The earliest description attributed to the species is by Francis Walker (Catalogue Lepidopterous Ins. Coll. Brit. Mus., part XVII, p. 399), who gave it the name *Isopteryx (?) obliteralis*. The type locality is "United States," the date of description, 1859.

The moth is of moderate size and may be recognized by the aid of the accompanying figure (fig. 28, *a*). The general color is described by Grote & Robinson, who gave a detailed characterization of the female under the name of *Botys maculenta* from Pennsylvania (Trans. Amer. Entom. Soc., vol. I, p. 23, 1867), as pale ochre-yellow. It is very pale, corresponding rather closely to, though lighter than, the "cream buff" of Ridgway's Nomenclature. The darker brownish markings are described as obsolete, and though rather faint or suffused in some places the pattern is usually quite constant though moderately variable in distinctness. In the paler individuals the lighter portions of the wings are translucent and more or less strongly iridescent. The lower surface of the wings is more strongly iridescent. In dark individuals, the marginal bands of the wings are sometimes very broad and heavy. The expanse of the fore-wings is about seven-eighths of an inch ($21\text{--}23^{\text{mm}}$). The body of the female is rather stout, and measures with the head about half the wing expanse.

The moth although nocturnal in habit is quite active when the least disturbed, and flies off with a quick darting motion.

The larva.—The larva is of unusual beauty. The general color when full grown is rather pale yellowish green, variegated with deeper green and with numerous very large and more or less rounded and polished somewhat rugose black spots, arranged as shown in the illustration (fig. 28, *b*). The head is a brighter yellow with orange mottling, as is also the cervical shield or anterior portion of the first thoracic

segment, the posterior portion being green. The head and two thoracic segments, with two pairs of legs, are shown at *d*, lateral view. The dorsal surface is darker yellowish and green, the dorsal line being conspicuous dark green. It is bordered each side by yellow, which extends to the rows of black piliferous warts. Each wart is surrounded more or less irregularly with grayish yellow and bears a yellowish brown hair. The second and third thoracic segments are tinged with blue, particularly about the warts. Altogether the coloring, together with the piliferous spots, impart to the larva a somewhat more striped appearance than the illustration shows. The lateral line is wide and very pale yellow. Ventral surface pale green, the legs pale yellow. Surface moderately hairy, the hairs proceeding from the black warts at the anterior portion of the body being light

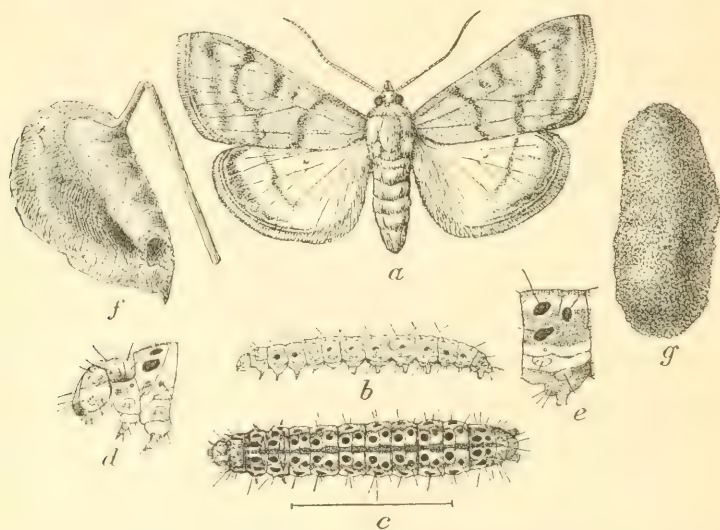


FIG. 28.—*Loxostege obliteralis*: *a*, female moth; *b*, penultimate stage of larva; *c*, last stage of larva; *d*, head and thoracic segments of same from side; *e*, third abdominal segment; *f*, work of larva; *g*, cocoon of hibernating individuals—*a*, $2\frac{1}{2}$ times natural size; *b*, *c*, *g*, 2 times; *d*, *e*, more enlarged; *f*, natural size (original).

brown, those from the posterior portion darker brown. The last segment bears no black spots, but is quite hairy. One of the abdominal segments is shown, lateral view, at *e*. The form is cylindrical and the folds of each segment are pronounced. The length is about six or seven times the width. The figure shows the larva in the somewhat contracted position assumed when at rest. Length when fully mature, 18–20^{mm}; width, 2.7–3^{mm}.

When the larvæ are full fed and have been for half a day or more without fresh food the ground color becomes almost uniform light yellow. At this period the striated effect is much diminished, although the black spots become more conspicuous, each one now showing a fine light ring about the insertion of the hairs.

The earlier stages differ in their paler color, the youngest larvæ being nearly white, and in having a much smaller percentage of the piliferous tubercular spots black. Only the lateral row is black, and of these the first thoracic and first abdominal are pale, the hairs being also pale, nearly white. The two pairs of thoracic spots are larger than the others, a character which is more pronounced in the earlier stages than in the antepenultimate. The penultimate stage of the larva is shown from the side at *b*.

The cocoon.—Transformation to pupa takes place in a cocoon, which, with the first generation, is often formed on the surface of the earth, sometimes attached to the dried leaves upon which it has fed. The cocoons of the second generation appear always to be formed normally beneath the earth's surface. The outer surface of the cocoon is covered with sand or earth, giving the appearance represented in the illustration at *g*. Such a cocoon divested of the outer grains of earth, which may be brushed off with a soft camel's hair pencil, measures about half an inch long and a fourth of an inch in diameter. Soon after forming its cocoon the larva becomes contracted to about half or a little less than half its length when fully extended when feeding.

The larvæ during the daytime are unusually sluggish as compared with other Pyralids, such as the grape leaf-folder (*Desmia funeralis*) and are not easily disturbed.

DISTRIBUTION.

The known localities for this species indicate a wide distribution, and it is probable that it is common from Canada to Mexico. The available list of localities includes the following: Washington and Georgetown, D. C.; Cabin John, Md.; Alexandria, Va., and Stillwater, Okla., from all of which specimens have been received. Grote and Robinson's type or types were from Pennsylvania. Lintner records Albany, N. Y., (vicinity); Smith, New Brunswick, N. J., and in the National Museum are specimens from Maine, North Carolina, Kansas, Texas, and Arizona.

DIVISIONAL RECORDS OF ATTACK.

The Divisional records begin with a note made by Mr. Pergande, August 21, 1884, when larvæ were found upon morning-glory in the District. In 1888 Mr. Pergande again observed this species in the District during July and August, feeding on sunflower and dahlia. It was also observed that year by Prof. W. B. Barrows on morning-glory.

Writing under date of July 4, 1896, Professor Bogue stated that he had reared this species (specimens of which were sent) from common morning-glory at Stillwater, Okla. Larvæ were observed to feed at night and to cut the petioles of the leaves upon which they were feeding in the manner previously described.

During August, 1898, Mr. Canatsey reported injury to cultivated morning-glory at Georgetown, D. C., which upon the receipt of specimens proved to be due to this species.

During the second and third weeks of the following June Mr. Keleher brought numbers of the larvæ, which from their peculiar coloration and markings are readily distinguishable, found on spearmint (*Mentha spicata*) growing in this city. Captures were made mostly toward dark, and larvæ were sometimes found at large upon the leaves, but more often in rolled-up leaves. Larvæ were also taken on morning-glory in the same neighborhood, but appeared to prefer mint. Later specimens were found by Mr. Keleher, July 5, feeding on the leaves of a young plum tree, and still later, up to September 28, larvæ were brought by him to this office found on morning-glory in this city and Alexandria, Va. July 8 the writer observed this species at work in a bed of cultivated peppermint (*Mentha piperita*) at Cabin John, Md.; August 21 he found larvæ feeding upon the rough hogweed (*Amaranthus retroflexus*) on the Department grounds; October 2 larvæ were observed on the same plant at Marshall Hall, Md., the leaves of which they cut in the same manner as the more useful plants. Morning-glory growing in the immediate vicinity was not noticed to be attacked.

LIFE HISTORY.

Moths that were placed in confinement, in the same manner as other species that have thus been successfully treated, failed to deposit eggs, and this stage was unfortunately missed.

From the lot of larvæ taken in August, 1884, moths began to issue May 28 of the following year, continuing till June 5.

The 1888 lot gave out moths February 11, 25, and March 9. This lot was evidently kept in an overheated room, which will account for what must be considered the premature appearance of the adults.

The larvæ taken in August, 1898, fed freely upon leaves of morning glory, with which they were confined, becoming full grown toward the end of that month. August 30 one of these formed its cocoon, in which it remained as larva until May 4 of the following year, when it transformed to pupa. The imago issued May 25, other moths continuing to issue until June 3.

The quiescent stage of the larva had thus lasted a little over eight months, and the pupal stage had lasted three weeks.

The remaining larvæ ceased feeding by September 8.

The first moth from the larvæ obtained in 1899, during June, was found to have issued early, June 5, the remainder issuing a few days afterwards. That there is considerable variation in the time of issuance was shown that year by our rearings, moths being present in our rearing jars as late as August 6.

According to Professor Bogue's observations, moths, evidently of

the second generation, emerged from pupæ in about ten days after the larvæ transformed. One of the larvæ captured in 1899 became full fed July 8, entered the earth the following day, and issued as moth July 22. Assuming the pupal stage to have lasted ten days, three days were passed by the larva in inaction.

It is obvious from the above that we have two well-marked generations and there is evidence also of a third generation, of few individuals. Although the earliest appearance of the moths in the field was not noted, it is fairly certain that they begin to issue from the pupæ of the over-wintered larvæ during the latter half of May and continue into June, depositing their eggs at this time for the first new generation, the moths of which appear during the last week of July and the first week of August. From the larvæ of the second generation cocoons were obtained August 14. In other words, larvæ had reached full growth early in the second week of August, and one lot had already entered the earth and spun up by the end of the second week. It has already been shown that larvæ of the second generation pass the winter in their cocoons, form the pupal condition in May, and about ten days after transforming issue as adults. There is evidence that a very small percentage of these, however, issue late in August and lay eggs for a small third generation, the larvæ of which have been observed by Mr. Keleher and the writer at the end of September and during the first week of October.

From the observed food plants it is obvious that we may expect attack in the future on several other plants. The present list includes morning glory, spearmint, peppermint, plum, sunflower, dahlia, and hogweed, plants of different botanical families.

NATURAL ENEMIES.

From the first generation of this insect a number of individuals of a parasitic Dipteron of the family Tachinidæ were reared, all of which evidently came from the cocoons. The species was referred to Mr. Coquillett, who identified it as *Hyppostena floridensis* Towns. Flies issued during the last week of July. This species, as its name shows, occurs in the South. Its known distribution extends from the White Mountains of New Hampshire to Jamaica, W. I. It has previously been recorded as a parasite of *Blastobasis nubilella* Zell. and *Schizocera ebena* Nort.

A nymph of the spined soldier-bug (*Podisus spinosus* Dall.) was observed by Mr. Keleher in the act of attacking a full-grown larva of this species the last week of September.

REMEDIES.

The earlier stages of this insect can doubtless be reached by a spray of Paris green or other arsenical, as to a certain extent also the latter

stages, when the larvæ poke their heads forth from their sheltered homes in search of food. The presence of the larvæ as they approach maturity and cut the leaves of their host plants may be readily detected, and at this time hand-picking is all that is necessary.

THE FICKLE MIDGE.

(*Sciara inconstans* Fitch.)

Some insect inhabitants of the greenhouse that have attracted attention in very recent years are the larvæ or maggots of certain species of midges or gnats belonging to the families Cecidomyiidae and Mycetophilidae. The larvæ of three species of the former family attack roses and violets, and one of them has been discussed in former pages of this bulletin on account of its injuries. A large proportion of the Mycetophilidae belong to *Sciara*, a genus of considerable extent, whose larvæ are believed to be for the most part scavengers, feeding upon decaying vegetable matter of different kinds, including fungus growths, whence the name of "fungus gnats" which has been applied to the family. Some of these larvæ live in vegetable mold, under the bark of trees, in putrefying vegetables, in manure, and some attack roots and sprouting seeds in greenhouses, and one of these, *Sciara inconstans* Fitch, the subject of the present paper, has recently been reported by various persons as being quite troublesome.

The subject of injuries by this species is a matter for future investigation, as there is a possibility that it agrees with other *Sciaras* in being a scavenger, and is, perhaps, in some cases attracted to the injured plants observed from the formation of fungus and other growths on them. It is to be regretted that the subject was not investigated earlier.

DESCRIPTIVE.

The adult of this insect is a minute two-winged fly or fungus gnat. Like others of the group to which they belong, these flies are exceedingly delicate, with moderately slender bodies, long slender legs, small heads, and rounded, moderately prominent eyes. The female of this species is shown in the illustration (fig. 29) at *c*. It may readily be distinguished from the male shown at *a* by its larger size, more robust abdomen when gravid, eyes somewhat smaller in proportion to its size, and particularly by the last abdominal segments. A side view of the tip of the abdomen of the female is shown at *f*, the maxillary palpus at *e*, and an enlarged section of the antennæ at *d*. At *b* is shown the peculiar structure of the external organs of the male. The general color of the body and legs is pale brownish yellow, with darker brown thorax, and black head. The wings are still lighter and lightly infus-

cated. The wing expanse is about one-fourth of an inch (5.5–7^{mm}), and the length of the body half that (3–3.5^{mm}).

The eggs are unknown, but they are probably like those of related species, white in color and of oblong shape and exceedingly minute.

The larva, shown at *h*, is a delicate threadlike creature, milk-white in color, with a distinct minute jet-black head. The average length is between 6 and 7^{mm}, the length being about eight or nine times the width, the latter being about 0.8 or 0.9^{mm}.

The pupa shown in the illustration at *g*, ventral view, is free (differing from the pupa of other Diptera in not being incased within its old larval skin). The length is about 3.5^{mm}, which is about three or four times the width. The color is pale yellowish, with darker wing-pads, and still darker head. The antennae and legs are folded down between the wing-pads, as shown in the illustration.

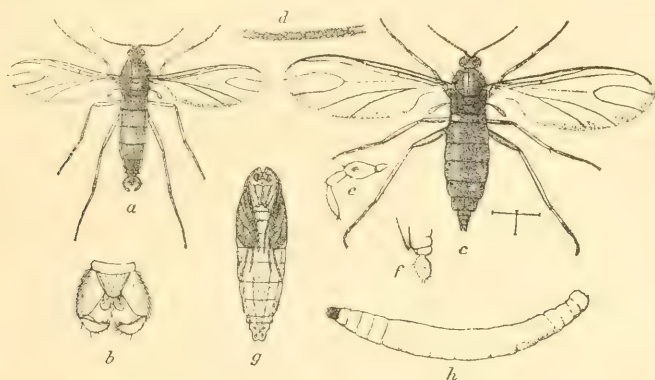


FIG. 29.—*Sciara inconstans*: *a*, male fly from above; *b*, external genital organs of the same; *c*, female; *d*, enlarged antennal joints of same; *e*, maxillary palpus of same; *f*, tip of abdomen of female from side; *g*, pupa ventral view; *h*, larva dorsal view—*a*, *c*, *g*, *h*, much enlarged; *b*, *d*, *e*, *f*, more enlarged (original).

DISTRIBUTION.

Owing to the difficulty of determination of these minute Mycetophilidae, little is known concerning their distribution. Since the description of *Sciara inconstans* at Albany, N. Y., we have learned of a few more localities, a number of which have just been mentioned. The list comprises the following: Ottawa, Canada; Orono, Me.; Jamaica, L. I., N. Y.; Kennett Square, Pa.; Clementon and Riverton, N. J. (Smith); Washington, D. C.; Richmond, Va.; Streator, Ill.; Wooster, Ohio, and Nebraska City, Nebr.

RECENT REPORTED OCCURRENCES.

During the past three years *Sciara inconstans* Fitch has been reported to be more or less troublesome in different portions of the country. Where specific identifications have been made, they are mostly on the authority of Mr. Coquillett, who has also kindly criticized the illustration of the insect here presented:

January 28, 1897, Mr. N. H. Reed, Nebraska City, Nebr., sent specimens, with report that the flies were swarming around his house during the winter, but that he could not ascertain where they came from. He stated that he had never been bothered with these insects before, although he had kept plants in his house for years. No specific injury was reported.

March 1 of the same year, Dr. James Fletcher wrote concerning what was probably this species, stating that the larvæ fed in numbers in the earth of house plants and were suspected of injury to them. The flies were very numerous upon the windows of houses at Ottawa, Canada. A remedy was requested.

January 24, 1898, Mr. F. A. Sirrine, Jamaica, N. Y., sent specimens, with the statement that the larvæ were reported to feed upon roots of roses. He called the adults "black manure gnats."

March 18 of the same year, the late F. L. Harvey, Orono, Me., sent specimens of larvæ and flies of what was identified as probably this species, doing damage to the bulbs of Gloxinia.

December 18, 1899, Mrs. Taylor, Kennett Square, Pa., sent specimens of this insect taken from the soil in potted plants, but with no report as to what plants were injured. The flies had been noticed about a month prior to the date of writing.

February 8, 1900, we received the larva of a species of *Sciara* from Mr. Harry McC. Dowdy, Richmond, Va., with report that this insect was injurious to peas growing in flower pots. These larvæ when received were boring into the cotyledons of the peas. February 14 we received another communication with specimens of the adult, which were identified as *Sciara inconstans* Fitch.

February 27 we received another sending of this insect, with report that the flies were swarming in a greenhouse belonging to Mr. R. D. Kline, a market gardener of Streator, Ill. Injury was feared and remedies requested. Our correspondent stated that no especial damage had been done to any particular plant other than to lettuce, which was affected merely by the presence of the adult insects. The dead bodies of the flies were stated to be abundant in the windows of one of his greenhouses, and for that reason were considered quite undesirable.

Writing March 5, 1900, Mr. Kline stated that he made a practice of "smudging" his six greenhouses, treating two houses one week, and then passing to the next two for the following week. He believes by this method he is enabled to kill off many insects, including the fickle midge, although numbers are left to breed.

Nitrate of soda and pyrethrum, as well as tobacco, were used by Dr. Fletcher upon this or a similar species of *Sciara* in Canada, but without entirely satisfactory results.

THE SAME OR A RELATED SPECIES REPORTED INJURING CUCUMBERS IN
HOATHOUSES.

Numerous complaints have reached this office of injuries to greenhouse plants of various kinds by this or related species of *Sciara*, but as it has been found impossible to obtain specimens of the adult the exact identity of the species remains in doubt. Injury to cucumbers grown under glass was a frequent subject of complaint. One instance of this nature may be cited as an example. November 28 and December 3, 1898, Mr. W. F. Preston, Dixon, Ill., wrote at considerable length, in regard to injuries by an insect which we identified as a species of *Sciara*, and which, he stated, was injuring cucumber vines in forcing houses in that city. There were, he said, at that time four plants for the growing of hothouse cucumbers for the Chicago market. Stable manure (horse) was considered the best fertilizer, and it was thought both by our correspondent and the writer that the presence of the insect was in part due to this manure. The small gnat-like fly with bluish wings was recognized as the parent of the maggot. As a remedy our correspondent had tried limewater, tobacco water, carbolic acid and water, bisulphide of carbon, sulphur, kerosene emulsion, fire-tree oil, and other substances, with no effect. Brine killed the insects, but also destroyed the vines. The insect was described as having cost the cucumber growers many hundreds of dollars during the year 1898. Messrs. Long & Co. made similar complaints of injuries in the same locality, our correspondence covering the subject extending from 1897 to 1900.

March 26, 1900, Miss Josie K. Carter, Bristol, Tenn., wrote in regard to the larvæ, which, judging from the description, was a species of *Sciara*, that was very troublesome to cucumber vines in that vicinity. The little thread-like worms were described as attacking the vines just under the surface of the earth and peeling the roots, making them look as if hot water had been poured over them.

LITERATURE OF THE FICKLE MIDGE.

The fickle midge was given its English as well as Latin name by Fitch in his second report on the insects of New York (p. 255), the description appearing as *Molobrus inconstans*, and drawn from individuals which had attracted his notice in December from the singular manner in which they ran about upon the paper on which he was writing. Flies were found at this time upon the windows, and it was believed that they had hatched from the earth in some flowerpots which were in the room. The fly was described as advancing two or three inches and then abruptly pausing or moving backward a step or two and instantly running in another direction for the same distance; then it would back up again and start off on another course.

As far as the writer is able to learn from a search through records available at this time, nothing further was gained in regard to the larval habits of the present species until a complaint of injury, by the larva, to the roots and bulbs of *Gloxinia* plants at South Deer Isle. This report was made by the late F. L. Harvey, in the Report of the Maine Agricultural Experiment Station for 1897 (p. 175). In the report for the following year (p. 127) reference was made to the same species, but the injury was attributed to an unknown species of Thrips. The person complaining of the injury placed slices of potato about the infested plants and the Thrips collected on them in great numbers.

In the September, 1899, number of *Entomological News* (Vol. X, pp. 201, 202), Mr. Jas. S. Hine published a note on this midge, with illustrations of larva, pupa, and of both sexes of the imago. Concerning injury, Mr. Hine says that the carnations in the greenhouse inspected were dying and that no cause was found except numbers of the minute white larvæ of this species which were boring inside of all the stems that showed serious injury. From all acquired knowledge of the habits of the *Mycetophilidæ*, Mr. Hine had supposed at first that the plants were killed in some other way and the insects were secondary in the nature of their attack, but by further observation he became convinced that they were feeding upon and injuring the growing plants.

NATURAL ENEMIES.

January 24, 1898. Mr. F. A. Sirrine wrote that the Anthomyiid *Ctenosia solita* Walk., was preying upon the adult gnats, appearing to feed exclusively upon this insect.

March 2, 1900, Mr. A. B. Eaton called attention to the occurrence of *Ctenosia solita* in the greenhouses of the Department of Agriculture, and to the fact that they captured other flies in the same locations. One was observed by Mr. Pratt and the writer having an adult of *Dolichopus spectabilis* Loew., a biting fly, in its mouth. They were also stated to be fond of the "white fly" (*Aleyrodes* sp.), and were frequently seen carrying the latter about while still alive. Many adult *Sciara inconstans* were found dead in the greenhouse, and it was thought that they had not only fallen victims to the *Ctenosia*, but that the presence of the latter in such numbers in the greenhouse had had considerable to do with keeping the gnats in check, as the gnats were comparatively rare, it being difficult to find living specimens at this time.

REMEDIES.

This insect is new as a pest, and we know so little concerning it and its food plants that it is a matter of some difficulty to advise as to the best methods for its treatment. We can, therefore, only suggest remedies that have been used with success against related species. What-

ever is used should be tested first in a small way before trying it on a larger scale. This is particularly true of remedies which might possibly harm the plants affected.

The hydrocyanic acid gas method would, of course, kill all of the adult insects, but would hardly have any effect whatever on the larvæ living and feeding beneath the surface of the ground.

Tobacco in various forms is the standard remedy against similar insects, and, if used in liberal quantities in proper manner, should always produce good results. Some of our correspondents report satisfaction with this remedy against other insects, while others report that it is not entirely efficacious. Refuse tobacco stems kept moist about the plants are sufficiently deadly in their effects on the adults as to keep them in subjection. Some of the juice which soaks into the ground would have the same effect on the larvæ, and tobacco is, moreover, a fertilizer of considerable value.

When practicable, it is always well to sterilize the soil or manure used in the greenhouse by placing it in large closed metal receptacles and subjecting it to about 150 to 200° F. of heat. The same object can be obtained by passing hot steam or hot air through the material used.

Bisulphide of carbon and kerosene emulsion applied to the soil about the roots of affected plants will kill the larvæ, but the former method is rather expensive.

A method of killing the parent flies said to be employed in mushroom cellars in Europe for similar species consists in placing small, lighted lamps in shallow pans filled with water with a little kerosene floating on the surface. This attracts vast numbers of flies, as well as other injurious insects that may happen to be in the greenhouse, all of which are immediately killed when they come into contact with the kerosene. This, though not a perfect remedy, may be of assistance in reducing the numbers of the pest.

Other remedies recently recommended against the related gnats which are the cause of potato scab, namely, solutions of formalin and of corrosive sublimate, should be tested where their use is indicated, as in the case of peas about to be planted. Full directions for this method of treatment and for the preparation of these two insecticides, which, it should be remarked, are fungicides as well, are given in Farmers' Bulletin No. 127 of this Department.

APPENDIX.

Since the present bulletin has been in the printer's hands, the writer has received a copy of Dr. James Fletcher's report as entomologist and botanist of the Experimental Farms of the Dominion of Canada for 1900, in which several of the species here treated are considered.

One of these is the variegated cutworm (*Peridroma saucia* Hbn.), which was the cause of a most remarkable outbreak in Canada, including British Columbia. This matter will be referred to somewhat more at length in a future publication on that species.

A somewhat similar but less formidable outbreak of the spotted cutworm (*Noctua c-nigrum*) was also reported in Canada, and as this latter species has been given more extended attention in the present bulletin it may be well to mention some of the more important features of the outbreak. Injury by this species in Canada was reported from Niagara and in several places north of Lake Ontario. It was also abundant at Ottawa. Almost all kinds of vegetation, with the exception of various grasses, were attacked, the larval habits assumed in this case resembling very closely those of the variegated cutworm. At Whitby the fruit of tomatoes were devoured, the cutworms eating through the skin and consuming the inside. Oats, peas, and cauliflower were also attacked. At Georgiana these cutworms stripped a field of carrots and mangels, devoured the leaves of Canada thistle, gooseberry, chokecherry, and peas, but a field of oats was left untouched.

A parasite of this cutworm (*Euplectrus frontalis* How.), was reared.

The greenhouse leaf-tyer (*Phlyctœnia rubigalis* Guen.).—A detailed description of the larva of this species and its manner of working is given with reference to injury to roses, violets, and chrysanthemums at Toronto the previous year.

The greenhouse leaf-roller (*Cacæcia parallela* Rob.).—During the year 1900 this species came under notice for the first time in Canada, from its attack upon the foliage of rose bushes in greenhouses at Hamilton, Ontario. Injury was first noticed in June, 1899. A good account, including a full description of the larva, is given.

BULLETIN No. 27.—NEW SERIES, REVISED EDITION.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY.

SOME INSECTS

INJURIOUS TO

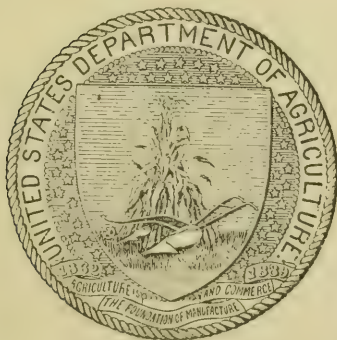
THE VIOLET, ROSE, AND OTHER ORNAMENTAL PLANTS.

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DIVISION OF ENTOMOLOGY.

Entomologist: L. O. Howard.

First Assistant Entomologist: C. L. Marlatt.

Assistant Entomologists: Th. Pergande, F. H. Chittenden, Frank Benton.

Investigators: E. A. Schwarz, D. W. Coquillett.

Assistants: R. S. Clifton, Nathan Banks, F. C. Pratt, Aug. Busek, Otto Heidemann,
A. N. Caudell, J. Kotinsky.

Artist: Miss L. Sullivan.



VIOLET LEAVES, SHOWING INJURY BY THE GREENHOUSE LEAF-TYER—NATURAL SIZE.

(From photograph by P. H. Dorsett.)

BULLETIN No. 27.—NEW SERIES, REVISED EDITION.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY.

SOME INSECTS

INJURIOUS TO

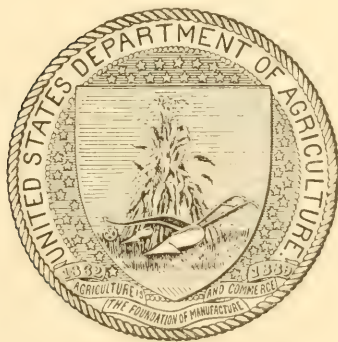
THE VIOLET, ROSE, AND OTHER ORNAMENTAL PLANTS.

A COLLECTION OF ARTICLES DEALING WITH
INSECTS OF THIS CLASS.

PREPARED UNDER THE DIRECTION OF THE ENTOMOLOGIST,

BY F. H. CHITTENDEN,

ASSISTANT ENTOMOLOGIST.



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LETTER OF TRANSMITTAL

U. S. DEPARTMENT OF AGRICULTURE,

DIVISION OF ENTOMOLOGY,

Washington, D. C., July 2, 1901.

SIR: I have the honor to submit herewith manuscript of a paper entitled *Some Insects Injurious to the Violet, Rose, and Other Ornamental Plants*, which has been prepared with admirable care and thoroughness by Mr. F. H. Chittenden, of this Division. The subject is one which has engaged Mr. Chittenden's attention for some time, and the investigation was necessitated by a very general complaint of damages by insects from growers of hothouse plants. The general subject is one which has not heretofore been treated, and the work is unquestionably needed. I recommend its publication as Bulletin No. 27, new series, of this Division.

This bulletin was originally submitted April 2, 1901, and the first edition was exhausted in a short time. There is still considerable demand for the information it contains and its republication is desired. In the reprint advantage is taken of the opportunity to slightly revise the bulletin.

Respectfully,

L. O. HOWARD, *Entomologist.*

HON. JAMES WILSON,

Secretary of Agriculture.

PREFACE.

Within the past three years insect injury to violets grown under glass has been very pronounced and has been the occasion of considerable correspondence and investigation in this Division and of experiment in the line of remedial treatment, conducted chiefly by the Division of Vegetable Physiology and Pathology of this Department. Messrs. A. F. Woods and P. H. Dorsett, of that Division, were in charge of this work, and the latter gentleman, who is also a practical florist, has furnished much material for the investigations conducted at this office. The insects which have been the occasion of the principal injury and which have received the larger share of attention in the present bulletin are five in number: (1) The caterpillar of a small moth, which we have called the greenhouse leaf-tyer; (2) the larva of a hymenopterous, which will be called the violet sawfly; (3) a plant-louse undescribed at the time work was begun on this class of insects and known to violet growers as the black or brown aphid or "black fly;" (4) the common "red spider," and (5) a small maggot called by florists the "gall fly." Several instances of injury by the larva of the moth above mentioned, to violets and other greenhouse plants, have been published; and the red spider is altogether too well known as a pest everywhere. None of these species has been at all fully treated biologically and economically in any of the publications in which they have hitherto been considered, and none has been figured in Departmental publications with the exception of the gall fly, which was described specifically in an earlier bulletin of this series. Numerous other insects have been observed upon violets in recent years, and some have been sent in by correspondents, particulars concerning which will be given. Certain common greenhouse pests other than those which will receive special mention, such as white grubs, wireworms, and sow-bugs, are occasionally troublesome to violets. Several species of cutworms have been observed from time to time attacking violets, and these will be considered with such other insects as have been recorded in our Divisional notes and in literature as occurring on this genus of plants.

Several other species of greenhouse pests, notably such as infest the buds and blossoms of roses, have been conspicuous in recent years, and certain of the more interesting of these will be duly considered in accordance with their injuriousness. Prominent among these are

little caterpillars known as rose leaf-tyers, rose gall flies (minute maggots, similar to those which attack violets), bud-worms, etc.

It was found impossible to complete certain of the studies planned and begun in 1898, owing to the scarcity of material (about Washington) the following years, but it is believed advisable not to further delay publication, as it is impossible to foretell when sufficient material will be available for our purposes.

Since the writer is not a special student of Lepidoptera he has preferred to use in the present work the lepidopterous genera in Smith's Catalogue rather than to adopt those recently proposed by certain European systematists, among whom is Sir G. F. Hampson, who has been for some time engaged upon the Pyralidæ. By so doing he believes that a certain degree of unnecessary confusion will be avoided, as it is by no means certain that the new generic arrangement of the European lepidopterists will be generally adopted in toto by Americans; and, until this matter has received the attention which is its due on the part of our students of this order, the old genera will be retained.

Mr. B. T. Galloway, Chief of the Bureau of Plant Industry, has discussed some of the principal insect pests of the violet in a little handbook, published in 1899, on the subject of growing and marketing violets for profit, and entitled "Commercial Violet Culture." The question of violet insects with the remedies to be employed against them is considered on pages 190-215 of that publication.

In the present bulletin all of the text figures designated as original have been drawn by Miss Lillie Sullivan, under the writer's personal supervision, and for the most part from selected fresh material.

F. H. C.

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SOME INSECTS INJURIOUS TO THE VIOLET, ROSE AND OTHER ORNAMENTAL PLANTS.

THE GREENHOUSE LEAF-TYER.

(*Phlyctænia rubigalis* Guen.)

One of the most troublesome of all known enemies of violets and other ornamental plants when once it obtains foothold in a conservatory is the greenhouse leaf-tyer, the larva of a small moth, now known as *Phlyctænia rubigalis* Gn., but formerly as *P. ferrugalis* Hbn.

Until within recent years only a few instances of injury by this species had come to our knowledge or been brought to public notice. During the past four years, however, its depredations have attracted attention in widely separated localities, and it is evident that this insect has now become established as a pest more than periodically injurious. As such it is entitled to somewhat extended notice. The greenhouse leaf-tyer, as its name would suggest, is more particularly annoying to ornamental plants grown in greenhouses; but its injuries do not cease here, since the larvæ work also in the field—celery, beets, cabbage, and tobacco, among crop plants, being most often affected.

NATURE OF INJURY.

The usual manner of work of the larva is upon the underside of a leaf. A fair specimen of larval injury to violets is shown in Plate I, which is reproduced from a photograph. The leaves figured were eaten out in holes on the under surface, leaving the upper epidermis intact, and this is the manner of injury to many other plants. Some plants, however, are eaten entirely through and some are skeletonized. Occasionally larvæ, when numerous, feed upon the upper surfaces of the leaves, but this is exceptional. The normal habit of the larva in feeding is to fasten together two contiguous leaves, to curl over the edge of a single leaf upon which it may be feeding, or to spin about itself a thin, filmy web within which to feed.

In close confinement a few larvæ will in a very short time devour and destroy their food plant. In one experiment in rearing this species at this office, larvæ completely destroyed a large pot of violets in ten days.

DESCRIPTION OF THE SPECIES.

The moth which produces the greenhouse leaf-tyer is a member of the family Pyraustidae, superfamily Pyralidina, and was first recognized and described from this country in 1854 (Guenée, *Deltoïdes et Pyralites*, p. 398). It is an inconspicuous little pale reddish-brown species

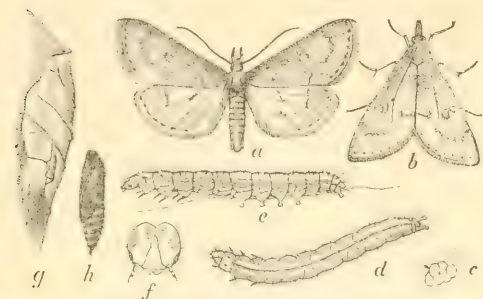


FIG. 1.—*Phlyctenia rubigalis*: a, moth; b, same in natural position at rest; c, egg mass; d, larva from above; e, same from side; f, head of same; g, pupa case; h, chrysalis—a, b, d, e, g, h, one-half larger than natural size; c, twice natural size; f, more enlarged (original).

with a wing expanse of about three-fourths of an inch. The fore-wings are light clay brown in color, suffused with a slightly darker reddish or ochreous brown, the serrate blackish lines with which they are ornamented forming the pattern shown in the accompanying illustration (fig. 1, a). The hind-

wings are gray, becoming light brownish toward the termen, and with two discal spots, the costal one prominent. Both wings are bordered with a row of small well-defined black dots.

The description of the moth by Mr. A. R. Grote, which appeared in 1877 under the name of *Botis harveyana* (Can. Ent., vol. IX, p. 104), is copied herewith for the further identification of the species:

A small species more slender than *communis*,¹ with pale, brown primaries, the exterior line fine, blackish, obsoletely denticulate, rather suddenly drawn in at vein 2, thence back again and angulate before the margin. Outer spot large, annulate. Inner spot obsolete. Before the fringes, which are faintly interlined with pale and are discolorous, there is a distinct sinus of dark points. Hind-wings paler than primaries, washed outwardly with the same brown as primaries, with a distinct discal dot and median line. Beneath more ochreous, with the discal dots double on hind-wings; a common exterior line; on the primaries the veins are partially darker marked; terminal points very distinct and continuous. Head, palpi, and thorax above pale-brown, beneath concolorous with under surface of wings glistening.

Dimensions: Fore-wings, 17–20 mm; hind-wings, 14.5–17 mm; length of body, 7.5–10 mm.

The venation and the shape of the head and antennæ is about as in *P. ferrugalis* shown in figure 2.

The moth bears a strong superficial resemblance to the common



FIG. 2.—*Pionea ferrugalis*: wing venation of moth at left; side view of head at right—enlarged (after Hampson).

¹ Presumably *Botis communis* Grt. (Can. Ent., v. VIII, p. 99=*Loxostege similalis* Gn.

garden webworm, *Loxostege* (*Phlyctænoides*) *similalis* Guen., but may be distinguished by the characters above given. That there need be no confusion of identity an illustration of this latter is also introduced for comparison (fig. 3).

NOMENCLATURE AND SYNONYMY.

Since the original description of Guenée in 1854 (l. c.) which appeared under the genus *Scopula*, the species has been described under the names *Botys oblongalis* Led. (Wien. Ent. Monatschrift, 1863, pp. 372, 469), as well as *Botis harveyana* Grt., and assigned to various other genera among which are *Margaritia*, *Phlyctæna*, *Pyrausta*, and *Pionea*.

In domestic lists and current literature this species has usually been mentioned as *Phlyctæna ferrugalis* Hbn., but it is at present catalogued by Sir G. F. Hampson (Proc. Zool. Soc. London, Feb. 21, 1899, p. 242) as *Pionea rubigalis* Guen. According to the usage of American systematists this species appears to belong rightfully to *Hapalia* Hbn., a genus which was proposed, though not described, as early as 1827, or twenty-seven years before Guenée's genus *Pionea*.

Phlyctæna rubigalis is, according to Hampson, native to North America and distinct from the Old World, and nearly cosmopolite *ferrugalis* Hbn.,¹ with which it has until very recently been confounded.

DISTRIBUTION OF THE SPECIES.

Grote's types of *Botis harveyana* were from New York and Texas. In the National Museum are specimens bearing capture labels of Illinois, 1876, and St. Louis, Mo., 1878. Published records and specimens now in the National collection are in evidence to show that the known distribution, though not cosmopolitan, is very wide, covering nearly our entire country from Canada to the Gulf States and from the Atlantic to the Pacific. The following are the known localities:

Toronto, Canada; Wading River, L. I.; Albany (Lintner), Poughkeepsie, Highlands, New York City, and Ithaca, in New York; Libonia, Pa.; New Jersey—throughout the State (J. B. Smith); Lakeland, Kensington, and Garrett Park, Md.; Tennallytown and Brook-

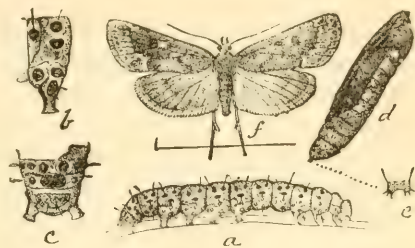


FIG. 3.—*Loxostege similis*: a, larva; b, side view of middle segment of larva; c, dorsal view anal segment of larva; d, pupa; e, cremaster of pupa; f, moth—a, f, somewhat enlarged; d, twice natural size; b, c, e, more enlarged (from Riley in Ann. Rept. Dept. Agr., 1885).

¹This latter species is recorded from central and southern Europe, Great Britain and Ireland, Western Asia, India, Ceylon, Burma, Japan, Afghanistan, western and southern Africa.

land, D. C.; Louisa County, Va.; Harpers Ferry, W. Va.; Wooster and elsewhere in Ohio; Indiana; Pekin, Urbana, (Forbes and Hart), Chicago, and central parts of Illinois; Kalamazoo, Mich.; North Carolina; Texas (Belfrage); Key West, Fla.; St. Louis, and central part of Missouri; Alameda (A. Koebele) and Los Angeles (Coquillett), Cal.

The fact of this species being so well established as a greenhouse pest and preferring indoor life to that of the field, is at least strongly suggestive of exotic and even tropical origin. From the above list of localities it will be seen that it occurs from semi-tropical portions of Florida through the Lower and Upper Austral life zones to what is at present considered Transition. For a species of its habits there is no reason why it should not become established, at least in greenhouses, still farther north in colder latitudes.

THE EGG AND OVIPOSITION.

Eggs are deposited singly or in masses of from two to nine or more; when laid in groups the different eggs composing it overlap as shown in the illustration (fig. 1, *c*). Many such groups may sometimes be found under a single leaf.

The egg. The egg is scale-like in appearance; when first laid, clear grayish white in color, and so nearly translucent as to show the color of the surface, e. g., the green of a leaf, upon which it is deposited; the exterior surface shining glassy and iridescent; flattened upon the surface of deposition; convex above and somewhat variable in outline but usually broadly ovate. The surface is rather strongly and rather finely rugose, irregularly subreticulate. The average length is about 0.8^{mm} and the width 0.65^{mm}.

THE LARVA AND PUPA.

The full-grown larva.—The larva when full grown presents the appearance indicated by *c* and *d* of figure 1. It is green or greenish yellow in color and somewhat translucent; the head is whitish and rather faintly spotted with small purplish spots (fig. 1, *f*'), and the first thoracic segment is marked on each side by a small but conspicuous round black dot. Along the dorsum the green ground color of the body shows as a narrow, rather conspicuous median green line, and on each side of this is a double line of white. The legs show on their outer surface two little round black dots and the prolegs are rather long and prominent. The surface is very sparsely hairy. The mature larva, when extended at full length in natural feeding position, is nine or ten times as long as wide, measuring about three-fourths of an inch (18–20^{mm}) in length and only about a twelfth of an inch in width (2^{mm}).

The pupa.—The pupa is dark, shining brown, and bears along its dorsal surface conspicuous hairs, as shown in the illustration (fig. 1) at *h*. It measures about three-eighths of an inch in length (7.5^{mm}).

Owing to the fact that the identity of this species with the closely related European *Phlyctenia ferrugalis* Hbn., which has been very carefully studied and described in detail in its several stages by the Rev. William Buckler in The Entomologist's Monthly Magazine for February, 1878 (pp. 200-204), was not for a moment doubted, no effort was made to watch the various molts or to make detailed descriptions of the larva while these could be obtained in fresh condition for the purpose. When the specific distinctness of the two species was recognized on receipt of the publication of Sir G. F. Hampson, previously cited, it was not possible, owing to the lateness of the season, to secure sufficient material for rearing.

The development of the embryo in the egg has been observed by Buckler in the case of the European species, and probably this does not differ much in the case of our own species. He states that the margin of the egg on the seventh or eighth day "becomes rounded or raised, and, like the rest of the upper surface, a little convex; the shell then is seen to be minutely pitted, and through it the whitish, wax-like, opaque, faint form of the larva coiled round can be just discerned; on the ninth day it shows more distinctly, and on the tenth the head can be plainly seen as a black spot on the margin; the shell is pearly and glistening; and after this the larva hatches in a few hours."

LITERATURE OF THE SPECIES.

The first notice that the writer finds which bears upon the biology of this insect was published in 1890 in the form of abstracts from correspondence in Insect Life (Vol. II, p. 277), further mention of which will be made under the heading of "Divisional Records of Injury." The species is there referred to *Botis harveyana* Grote.

In 1893 Mr. G. C. Davis gave a short popular account of this moth, with original illustrations of its different stages, in Bulletin No. 102 of the State Agricultural College of Michigan (pp. 28, 29).

In his report on the insect injuries in Maryland in 1897, Prof. W. G. Johnson mentions the finding of the larva injuring the young and tender lower leaves of tobacco in a hotbed at the Maryland Agricultural Experiment Station (Bul. 9, n. s., Div. Ent., p. 83; Bul. 57, Md. Agl. Expt. Sta., p. 7). They were noticed in abundance from July 1, and most numerous July 13. In the Florists' Exchange for October 23 of the same year, Mr. P. H. Dorsett, of this Department, gives a few notes on this moth and its injuries to the leaves of violets, illustrated with a half-tone reproduction of a photograph of the insect, natural size, in its different stages and its work.

It should be added that Mr. Dorsett met with this insect also at Poughkeepsie and Highlands, N. Y., and he informs the writer that it was troublesome in greenhouses there and elsewhere along the Hudson River valley.

The same year Mr. James S. Hine published a very good three-page account of this species, with original observations upon its life history, in the Columbus Horticultural Journal (reprint, dated September 28, 1897, pp. 1-4).

In the edition of the Weekly Florists' Review, of Chicago, Ill., for March 3, 1898, the writer published a short preliminary account of this insect in answer to the inquiry of a correspondent of the Review, who requested a reply through the columns of that periodical.

Under the heading *Phlyctænia ferrugalis* Mr. Galloway mentions this species on pages 214 and 215 of his work "Commercial Violet Culture," published in 1899, giving a half-tone illustration of the insect and its injury, from photographs of the same.

This species was included in a list of the principal injurious insects of the year 1899, with brief mention of reported injury to violets in Maryland and Virginia and to other greenhouse plants in New York and Canada, in the Yearbook of the United States Department of Agriculture for 1899 (1900), page 746.

It has also received brief mention under the name of the chrysanthemum leaf-skeletonizer in a paper entitled Insects Infesting Carnations, by F. A. Sirrine, published in the American Florist for March 3, 1900 (Vol. XV, p. 912). Chrysanthemums were stated to be subject to attack particularly when roses were grown in the same house.

In Bulletin No. 60 of the University of Illinois Agricultural Experiment Station, also published in 1900, Messrs. Forbes and Hart have a short article on this species (pp. 453, 454), which was found attacking beets at Urbana and near Pekin, Ill.

In a recent publication by Dr. James Fletcher (Transactions Royal Society of Canada, Vol. V, second series, 1899-1900, p. 228) mention is made of this leaf-tyer in connection with its occurrence in Canada upon the leaves of roses in greenhouses. It was reported to have done very serious damage three years previous to the time of publication, necessitating the entire cleaning out of a large house of choice roses. In the same writer's report, as entomologist and botanist to the Canada department of agriculture, central experiment farm, for 1899 (1899), pages 179, 180, and in the Report of the Entomological Society of Ontario, for 1899 (1900), page 110, more detailed accounts of this same attack are given, with notes.

Mr. Davis has called this insect the celery borer, from the habit of the larva of boring into celery stems; but this habit is evidently an exceptional one, as it is normally a leaf-feeder, and, although its habits vary, it usually joins together the leaves of the plant upon which it feeds. It appears to feed by preference also upon the terminal leaves of most plants and upon such plants as are growing in dark or protected situations. As the species is omnivorous and, so far as observed, a pest chiefly in greenhouses, the writer some time ago proposed the

name of greenhouse leaf-tyer, a cognomen which has already been adopted.

DIVISIONAL RECORDS OF INJURY.

What is probably the first rearing of this species is that of June, 1888, in the laboratory of this office. The 23d of that month Mr. Theo. Pergande found larvæ and pupæ in one of the conservatories connected with this Department. They had done much damage to a number of small plants of the nodding thistle, *Carduus* [*Alfredia*] *cernuus*, a European plant sparingly introduced about some cities in the Eastern United States. These larvæ had completely skeletonized the plants, causing them to dry up. From this lot moths were reared June 28. On September 14 of the same year were received larvæ and pupæ from Mr. E. S. Miller, Wading River, Queens County, N. Y., with the statement that the larvæ were doing much injury to all kinds of "soft-wooded" greenhouse plants (Insect Life, Vol. II, p. 277).

The writer's first experience with this species was on July 7, 1893, when it was observed in all stages in a conservatory at the World's Columbian Exposition at Jackson Park, Chicago. One of the exhibitors in the Horticultural Building showed the writer specimens of the moth, and stated that it was very injurious to dried apples from Missouri and Idaho. A personal visit to the building resulted in the discovery that the dried apples were, in reality, injured by the Indian-meal moth (*Plodia interpunctella* Hbn.); but by striking some of the ornamental plants in the conservatory with a cane the moths of this leaf-tyer were induced to fly up and were captured. A careful search of the plants upon which the moths were most frequently noticed led to the finding of the larvæ. The plants mostly attacked were the wandering jew (*Tradescantia zebrina*), ground ivy (*Nepeta glechonoides*), and geranium, the last being least affected. It was noticed that the larvæ fed chiefly upon the terminal leaves, and, for the most part, on the under surface. They were surrounded usually by a slight silken web, and where two leaves were in contiguity they were often fastened together with the silk, and sometimes a single leaf would be folded. Unfortunately, observations were not carried on as intended, owing to the fact that the exhibitors having charge of the conservatory evidently became suspicious of the frequent visits of a "Government official," and, no doubt, fearing that publicity might be given of the facts in the case, kept a sharp lookout for insects of every kind, and destroyed every insect in sight. Mention is made of this fact because it resulted in a test of a good but somewhat tedious remedy. August 7 only a single moth could be found and no larvæ. Soon after the writer's first visit in July the attendants trimmed the infested plants and they were afterwards trimmed as often as the larvæ showed themselves. As already stated, the larvæ affect more especially the terminal leaves of

these particular plants, and these were destroyed after being cut off, presumably by being crushed under foot. One of the attendants stated that the plants had also been dosed with a strong tobacco wash, which probably affected such larvæ as might have remained on the plants.

July 23, 1897, Mr. F. C. Pratt found numerous individuals of the moths as well as larvæ on celery at Brookland, D. C. An average of about three pupæ were found spun up in the leaves at the tops of all the young plants, and when the plants were brushed with a stick or by hand the moths "rose up in clouds." The owner of the place where the insects were at work stated that this species had been a most troublesome pest the previous year; its habit of feeding upon the tops of the celery greatly lessened its market value. It was his first year in celery raising in that locality, and he had conceived the idea that it would not be profitable to raise that crop there. In succeeding years, however, there was a decided decrease in the numbers of this leaf-tyer. When the place was visited by the writer in 1899 and in 1900 the insects were comparatively rare.

During January and February, 1898, this species was the subject of correspondence between this Division, the Florists' Review, of Chicago, Ill., and Mr. Robert Mearns, a florist, of Toronto, Canada. The latter sent specimens in all stages, with the report that this insect was doing much damage to plant life in the greenhouses of some of the florists in that city. The florists were very anxious to learn of an effective remedy for the pest. Larvæ were particularly destructive to heliotrope, wallflower, violet, and geranium.

April 28, specimens of the moth and pupa of the greenhouse leaf-tyer were sent to this office by Mr. S. S. Wilson, Libonia, Franklin County, Pa., with the statement that the larva was very injurious to greenhouse plants, such as geraniums and dahlias. From this lot one moth was obtained April 30. May 17, the same gentleman made another sending of material and, in response to inquiry, furnished a list of the plants affected in his greenhouses. This list includes *Ageratum*, geranium, German ivy, Kenilworth ivy, ground ivy, dahlia, *Justicea*, chrysanthemums, *Chicoraria hybrida*, anemone, cabbage, *Matricaria*, *Passifloras*, *Plumbago*, *Ruellia*, *Tydaea*, daisy, *Lobelia*, *Veronica imperialis*, *Lantana* and *Deutzia*. Larvæ were first noticed at that place about the 1st of January, in 1898, on *Ageratum* in a hot place in one of the greenhouses, and next upon geraniums. At the time of this writing it was feared that if their ravages were not checked they would eat all the near-by plants. It was noticed that they had a special fondness for forming their cocoon-like pupal cases on *Anemone japonica*.

May 14, 1898, Mr. Pratt called the writer's attention to the great numbers of the moths of this species that were present in a large field of rhubarb at Tennallytown, D. C. When the field was visited again on the 17th it was found that this was by far the most abundant spe-

cies of moth then present in that locality. They began hovering about the plants before sundown, often several individuals being in sight at one time. A considerable proportion alighted upon the rhubarb leaves and immediately crawled to the lower surface and disappeared when not molested, while others alighted upon clover and weeds in the same field.

Again the following year moths were observed in the same fields and elsewhere early in the season, but careful search failed to reveal any larvæ. The only wild plant from which the species has been reared here is hedge mustard (*Sisymbrium officinale*). Imagos issued June 10-17.

Attack upon field crops and weeds, aside from celery, is not so obvious as in the greenhouse, the larvæ being distributed here and there in such manner that they can do little harm. Hence it follows that larvæ are rather rarely found out of doors, though the abundance of the moths show that they undoubtedly are present and often in some number, on a great variety of crop plants and weeds.

Later in the season of 1899 the species when sought for was rarely found. Mr. Dorsett was able to obtain only three larvæ from his violet greenhouse, and search by the writer in several beds of celery failed to be productive of many individuals.

November 15, 1899, Hon. G. W. Koiner, Richmond, Va., sent specimens of this species, among others, that were depredating on violet beds in Louisa County of that State.

January 12, 1900, Mr. Franklin Sherman, jr., wrote that this species was breeding at Ithaca, N. Y., on a great variety of plants, and had made itself quite a serious pest in the forcing houses during that winter.

In a letter of the same date Dr. James Fletcher reported attack by this species in greenhouses in Canada.

The foregoing mention includes only such plants as the larvæ have been found to select for themselves. In confinement, larvæ, after devouring the potted plants upon which the eggs had been deposited, were fed with bean leaves, which happened to be the most available plants on which to feed them at the time. It appears probable that larvæ would thrive on almost any succulent vegetation, with perhaps the exception of conifers.

In addition to the plants above mentioned, there is a Divisional record of this moth having been reared from some species of ragweed or pigweed (*Ambrosia*) from central Illinois.

HABITS OF THE LARVA.

Soon after hatching, the larva begins feeding, at first cutting little patches of parenchyma from the under surface of the leaves, leaving the upper epidermis intact, as shown in the illustration of an affected

violet plant in Plate I. A few days later it usually seeks concealment by drawing together by means of its fine silken webbing portions of a leaf or of two leaves that happen to be contiguous.

The terminal leaves of such creeping plants as the wandering jew appear most subject to attack, while the lower leaves of taller plants are most injured. As in the case of many other greenhouse insects, the larvæ prefer secluded places, and plants growing in shady locations are most affected.

When full grown the larva prepares for pupation in different ways. Sometimes it will spin up between two leaves, but more often rolls up a pupa case at the edge of a leaf, if the leaf be large, cutting a slit usually on one or both sides before drawing the leaf over itself. The interior it lines with a thin silken membrane, and within the cocoon thus formed changes to pupa. In figure 1, *g*, a pupal case showing slit on one side is illustrated.

Individuals that were observed in May would be feeding one day and the next would form their pupa case and the same or the next day would transform.

HABITS OF THE MOTH.

As has already been stated, the moths fly just before sundown. Indoors they rest during the daytime on the lower surface of the leaves of their food plants and other low-growing plants and doubtless remain thus for many hours at a time unless disturbed. When disturbed they fly only a very short distance before they alight and at once seek the underside of a leaf again. They fly low and if along the ground they alight only to again fly up until the underside of a leaf is found. In these habits they resemble many other moths that could be mentioned. The position taken by the moth when at rest on the under surface of a leaf is shown in figure 1, *b*.

DEVELOPMENT AND GENERATIONS.

It will be noted, in Buckler's account of the development of the egg of the European *Phlyctenia ferrugalis*, that hatching took place on the tenth day. With our native leaf-tyer, eggs that were found on rolled violets in a rearing jar in which moths had been placed May 11, and which were presumably laid on that date, hatched May 23, or in twelve days.

The oldest larvæ of this lot attained full growth and began crawling about the rearing jar, June 10; on the 11th began spinning, and on the following day had pupated, thus giving twenty days as the duration of the larval stage. The individuals which developed into pupæ June 12, transformed to imago June 19, giving seven days as the duration of the pupal period for this time of the year. The weather averaged about normal, the temperature being 75-86° F.

The duration of the first generation observed was therefore thirty-nine days.

There is little doubt that in confinement a generation of this species is produced which issues in April and May. The writer, therefore, feels justified in considering the first generation reared at this office as the second indoor one. Of the development of the first generation, then, nothing can be said.

A larva from the hypothetical first generation was observed to begin the construction of its pupal case May 13, on the following day it spun up and over night changed to pupa, the imago issuing during the night of May 23, the duration of the pupal period for this individual having been nine days. A second individual went through this process in the same time, beginning to spin up May 16, completing its work the following day, being found as pupa next day and issuing as adult on the 27th; the weather was cool. In hot August weather the pupal condition consumed seven days.

The midsummer generation, as observed at this office, may be passed in thirty-four days; or, we may say, in about five weeks. The egg state required but five days, and this with the pupa seven, leaves twenty-two days or about three weeks for the larval period.

In an exceptionally low temperature in which a midwinter generation was reared under artificial conditions, neither that of a conservatory nor the field, where the temperature varied from 42° to 62° F., eggs laid January 19 hatched thirty-four days later, or in about five weeks. The larval period was prolonged about two weeks, and the imagoes, which laid the eggs in this experiment lived, some of them, a month, and one for six weeks.

The larva has been traced through its molts by Mr. Hine, at Columbus, Ohio (l. c.). In greenhouses he found that the larva makes its first molt in eight days after hatching, and at intervals of about five days thereafter, having four molts in all, the duration of the last stage—that is, after the fourth molt—being about eight days. The duration of these molts in a close conservatory in hot weather would, of course, be a day or two less.

Two and probably more generations are unquestionably produced annually in the open, and in hothouses a still greater number. At least four are indicated for the average indoor temperature of a conservatory.

On this head, Mr. Hines says: "It is evident that at least five generations are produced in the interval between the middle of September and the middle of the following May, or the time during which most commercial greenhouses are in operation."

Divisional records and those of captures show that moths have been taken out of doors as early as April in central Illinois and central Missouri, and in May in the District. Moths have been reared under

more or less unnatural conditions, but similar to what are experienced in greenhouses in every month throughout the year.

LIST OF FOOD PLANTS.

The known host plants of this species may be summarized as follows: Celery, cabbage, beets, and tobacco, among crop plants; and of greenhouse and other ornamental plants, *Ageratum*, geranium, ground ivy (*Nepeta glechoma*), German and Kenilworth ivy, violet, heliotrope, wall flower, wandering Jew (*Tradescantia zebrina*), dahlia, daisy, *Justicea*, chrysanthemum, carnation, *Cineraria*, begonia, abutilon, roses, pelargonium, anemone, nasturtium, moonvine, *Swainsonia*, *Genista*, *Plumbago*, *Matricaria*, *Passiflora*, *Ruellia*, *Tydaea*, *Lobelia*, *Veronica*, *Lantana*, *Deutzia*, nodding thistle (*Carduus*), and ornamental *Ambrosia*. Of weeds it has been observed on hedge mustard (*Sisymbrium officinale*) and ragweed (*Ambrosia*).

SUMMARY OF THE LIFE HISTORY.

The life history of the insect is now practically known, and the summary which follows is fairly complete. This species occurs out of doors, where it sometimes does considerable damage to celery, but aside from this its injuries are confined, for the most part, to plants in conservatories.

The moth lays its scale-like white eggs on the plant which is to serve as the food for its larvæ. The eggs hatch in from five days to about three weeks, according to temperature.

The larva, soon after it is hatched, usually conceals itself or begins the process of doing so by drawing together, by means of its white silken web, a portion of a leaf, or it thus joins two contiguous leaves and feeds upon their lower surface. The work of the larvæ has been most noticeable in secluded situations, and, on most plants, upon the terminal leaves, which they eat full of holes. They work chiefly at night, and by day rest in the same location; here also they transform to pupæ or chrysalides, and subsequently to the imago or moth state. Occasionally, at least, perhaps in the case of the hibernating generation out of doors, the larvæ seek more protected locations for their transformations.

Hibernation either begins in the larval state and ends toward the approach of warm spring weather with the pupa, or is passed in the pupal condition. In warm indoor temperatures there is no definite hibernating period.

The larval period varies also, according to the temperature at the time of transformation, from an observed minimum of about three weeks to perhaps five weeks, and the pupal period from one to probably two weeks.

NATURAL ENEMIES.

A single parasite of this species has been observed, the only natural enemy that appears to be known for it. Among a lot of larvæ from Libonia, Pa., a cocoon was found May 19, which gave the imago May 27. It was identified by Mr. Ashmead as a species of *Synetæris*, an ichneumonid genus related to *Limneria*.

REMEDIES.

Hand-picking.—The greenhouse leaf-tyer can be controlled in greenhouses by hand-picking or trimming away and destroying all infested leaves or other portions of plants as often as they are detected. This has been successfully practiced in a number of cases, one of which has already been mentioned, but it is somewhat laborious. Mr. Wilson wrote in regard to this species that he entirely rid his greenhouse of it one season by hand-picking.

Attracting moths to lights.—Another method of checking the increase of the species is by attracting the moths to lights placed in the greenhouses at night. This method is in practice by at least one of our correspondents, who reports that it affords some relief. Lights to be most successful should be placed over vessels of water on which a thin scum of kerosene is floating.

In any case a careful lookout should be kept for this and other insects which injure the plant by eating its leaves.

Arsenical spray.—Paris green or other arsenical would, if applied at the outset of the attack, effect the destruction of the larvæ, but it has not been ascertained by practical experience whether or not such a spray would destroy the more mature larvæ. Owing to their more or less protected manner of working, it would probably not do so effectually. An underspraying is, of course, a necessity.

This and hand methods are about the only remedies applicable to celery beds and elsewhere out-of-doors. An objection to the use of Paris green on violets and some other greenhouse plants is that the plants have to be syringed every few days for protection against the so-called "red spider," and this would wash away the arsenite. Another is that a poisonous wash could not be used when the plants are in bloom. It might also injure the foliage of certain tender plants. It is better to use some remedy that will at the same time destroy other insects with which the greenhouse may be affected.

Tobacco as a greenhouse fumigant.—The most widely useful insecticide for greenhouse fumigation is tobacco in its various forms. In many instances it is without doubt the cheapest and safest insecticide to use against certain greenhouse insects, particularly plant-lice. Its effectiveness, however, under the best conditions is not great, as it

requires repeated use at short intervals. Moreover, it may cause serious injury to some plants. On the other hand, tobacco may prove injurious to the foliage and flowers of certain plants such as violets, by bringing on epidemics of "spot." Tobacco is also useless against scale insects in general and mealy bugs.

Hydrocyanic-acid gas treatment.—The most satisfactory manner of dealing with the insect enemies of violets and some other greenhouse plants is by means of hydrocyanic-acid gas which has been developed as a medium for the fumigation of greenhouses by Messrs. A. F. Woods and P. H. Dorsett, of the Division of Vegetable Physiology and Pathology of this Department. Instructions for its use were given by these gentlemen in Circular No. 37, 2d Ser., of this Division, from which publication the directions which follow on this method have been largely transcribed.

This remedy has proved particularly effective against aphides, and has the advantage of being more or less useful against many other insects except the so-called red spider, which it does not entirely destroy, but it can not yet be safely used for the fumigation of certain other plants owing to the danger of bleaching and otherwise injuring them; hence it will be wise, before undertaking fumigation on a large scale on plants which will be mentioned, to first use this remedy experimentally on a few plants and in a small way.¹

THE HYDROCYANIC-ACID-GAS METHOD OF FUMIGATING GREENHOUSES AND COLD FRAMES.

Hydrocyanic-acid gas, since its introduction by the Division of Entomology in 1886 as a remedy against scale insects of the orange, has proved of great value as an insecticide. Previous to our experiments early in 1895, though it had been occasionally tried in greenhouses, hydrocyanic acid was not recommended on account of its injurious effects upon plants. As a result of a series of careful experiments we found that, as a rule, plants were less injured by a short exposure to a relatively large amount of gas than they were by a long exposure to a relatively small amount. On the other hand, a strong dose for a short time was the most effective in killing insects. Different species and varieties of plants, however, were found to vary remarkably in their power of withstanding the poison. This in many cases appeared to depend upon the open or closed condition of the breathing pores, as well as upon peculiarities of the cell contents. Fumigation an hour or two after sundown, with the temperature as low as practicable, was found to give the best results. In each case the proper amount of gas to use and the length of exposure must be determined by experiment. It is impossible at present to give a general rule applicable to all plants in all stages of development. When the conditions are once determined they

¹ In Galloway's *Commercial Violet Culture* (p. 215), where similar advice for the treatment of this insect is given, the statement is made that "Where this gas is used for other pests, the insect in question is easily kept in check." The writer is of the opinion that this is true, but it is to be regretted, in the face of experiments that have been conducted by Mr. M. V. Slingerland (Bul. 190, Cornell Univ. Agr. Exp. Sta., May, 1901, p. 163), that he (the present writer) was not more guarded in his expressions concerning the efficacy of this remedy in the first edition of this bulletin. Mr. Slingerland tested this gas against this leaf-tyer, and his experiments show that the gas does not kill moths, pupæ, and grown larvæ when used at the ordinary strength, but only small larvæ. These results agree with some experiments that have been made by the writer on other caterpillars; still it is the experience of Messrs. Galloway, Woods, and Dorsett that where this gas is frequently used the leaf-tyers will be greatly reduced in numbers if not held under practical control.—F. H. C.

must be strictly followed to insure the greatest success. Methods of experimenting will be described in the latter part of this circular. The quantity of gas in each case is always given in terms of the potassium cyanide from which it is made, and on a basis of a cubic foot of space, as will be explained more in detail further on. The cyanide, as well as the gas made from it, is exceedingly poisonous, and both must be used with the greatest care.

CROPS AND PESTS ON WHICH THE GAS HAS BEEN SUCCESSFULLY USED.

Ferns.—For *Davallia mooreana* infested with a scale insect (*Chionaspis* sp.), 0.075 gram of 98 per cent potassium cyanide should be used for each cubic foot of space to be fumigated, not deducting the space occupied by the plants. Length of exposure, twenty minutes.

One hundred and fifty to two hundred plants with fronds in all stages of development have been thus treated two or three times each year for the past four years with no injury to the plants and almost complete destruction of the insect. They were treated fifty at a time in a fumigating box (fig. 4.), described later.

Adiantum cuneatum and *A. Ballii* have been tried on a small scale and were not injured by the treatment.

Coleus.—"Golden Bedder," "Verschaffeltii," "Shylock," and others. 24,000 plants in pots, badly infested with the "white-tailed" mealy bug (*Orthezia insignis*). The house contained 15,587 cubic feet of space. Treated at the rate of one-tenth of a gram of 98 per cent cyanide of potash per cubic foot of space for twenty minutes, one hour after dark. *Orthezia* all killed and plants not injured in the least. All

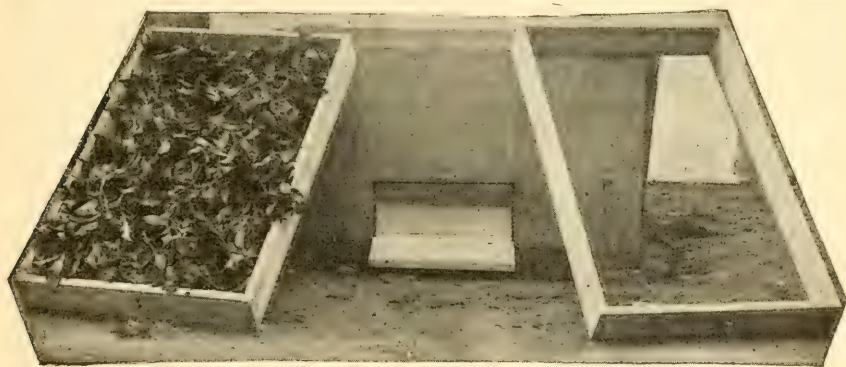


FIG. 4.—Fumigating box showing trays and coleus cuttings (from Woods and Dorsett).

other means of destroying the *Orthezia* had been tried without effect. Large numbers of the common mealy bug were also killed by this treatment; but it was not nearly so effective as for the "white-tailed" mealy bug. All coleus cuttings made by the United States Propagating Gardens for the past two years have been fumigated before being prepared for the cutting bed (see fig. 4).

Double English violets.—"Marie Louise," "Lady Campbell," and others. For plant-lice and general fumigation fifteen-hundredths of a gram of 98 per cent cyanide of potash for each cubic foot of space is required. The exposure, if made according to directions, will not hurt the plants in any stage of growth. The gas has been used on a large scale in fumigating violets for the past three years with the greatest success, only a few treatments during the season being required. Leaf-eating larvæ, slugs, millipedes, cutworms, etc., when exposed are killed as well as plant-lice. Red spiders, however, are not entirely eradicated by the treatment. The foliage of single violets like California and Princess of Wales are sometimes slightly injured by the stronger dose of gas. A weaker dose (one-tenth of a gram potassium cyanide per cubic foot) should be used when they are to be treated.

Other plants.—Other plants on which the gas has been tried on a small scale indicate that it may probably have quite a wide range of usefulness.¹

Roses.—"Perle des jardins," "Mermet," and "Bride." The young growth on roses is particularly sensitive and has been more or less injured in all our experiments.

Carnations.—Scott, Garfield, Meteor, and McGowan will stand one-tenth of a gram of 98 per cent cyanide per cubic foot of space for 15 minutes without material injury. This will kill about 90 per cent of the plant-lice, but will not kill thrips. The use of the gas for carnations needs to be more carefully investigated before it is recommended. The same is true of chrysanthemums, on which it has been tried with only partial success, the young growth being very sensitive.

Grapes under glass.—The gas has been used with success in New Zealand² for mealy bugs (*Dactylopius adonidum* L.) at the rate of one-third of an ounce 98 per cent cyanide to 100 cubic feet. This is equivalent to nine-hundredths gram per cubic foot. The gas is liberated after dark and left in till next morning, when thorough ventilation is given. It largely escapes, however, during the night. The treatment is said not to injure the plants in the least.

Tomatoes.—Dr. Jabez Fisher, in "American Gardening" (Oct. 29, 1898), reports using the gas for "white fly" (*Aleyrodes* sp.) on tomatoes. The gas from one ounce of pure cyanide of potassium for each 1,000 cubic feet left in the house over night killed all the insects without injury to the plants. This method has not yet proved successful with us in any case, but it should nevertheless receive careful trial by other experimenters.

CUBIC CONTENTS OF THE HOUSE.³

In all cases where fumigation with this gas is to be followed it is necessary to first determine accurately the cubic contents of each house. The determination of the cubic contents of the house, while in itself a comparatively simple problem, has, in the eyes of many growers, difficulties which they are not willing to undertake. The cubic contents can be determined by a comparatively simple mathematical calculation, but perhaps the easiest way is by a method recently described by the writer in the Florists' Exchange [Vol. II, no. 5]. This method involves nothing more difficult than the mere counting of a number of squares, and from an examination of the accompanying illustration [fig. 5] the simplicity of the method will become apparent. Procure from a stationery store or art supply store some cross-section paper, such as represented in the figure. In this particular case squares of three sizes are shown, the largest being one-half inch, the next one-fourth inch, and the smallest one-sixteenth inch square. The one-fourth inch squares may represent feet. Now determine the dimensions of the house—that is, the length, width, height to ridge, and height on sides, and make a sketch as shown, each square or one-fourth inch representing 1 square foot. This particular house, it will be seen, is 18 feet (18 squares) wide, 12 feet to the ridge, 6½ feet high at the back, and 4½ feet high in front.

The ridge stands 5 feet from the back wall, as shown in the sketch. After the lines are drawn, simply count the squares inclosed, and the number of squares will be the number of square feet. The parts of squares, that is, where a line divides a square, can be easily determined by counting the smallest squares, or by the eye, and by adding these fractions of squares together the number of whole squares may be readily found. After the number of square feet is obtained it is only necessary

¹ The gas has been used on the following plants at the rate of one-tenth gram of cyanide per cubic foot of space for twenty minutes without injury. Further experiment, however, is necessary before the treatment can be recommended for these: *Alocasia Macrorrhiza variegata*; *Anthurium crystallinum*; *Arceia lutescens*; *Aralia filicifolia*; *Adiantum cuneatum*; *Adiantum Ballii*; *Campylobotrys refulgens*; *Cissus discolor*; *Crotons* (in variety); *Cichorium intybus*; *Diffenbachia Lenmanii*; *Ficus elastica*; *Fuchsia* (in variety); *Jacaranda mimosifolia*; *Marantas* (in variety); *Nymphaea candidissima*, and *odorata rosea*; *Pontederia crassipes*; *Pandanus veitchii*; *Phrygium variegatum*; *Phyllotenum Lindenii*; *Panax Victorie*; *Stenanthium Lindenii*.

² Fourth Report, Dept. of Agr., New Zealand. 1896. Pp. 141-143.

³ The method described is quoted from B. T. Galloway's Book on Violet Culture.

to multiply this by the length of the house in feet and the result will be the cubic contents. For example, supposing the house in question is 100 feet long, it contains $150\frac{1}{2}$ squares or square feet, and $150\frac{1}{2}$ multiplied by 100 equals 15,050 cubic feet. The whole operation requires less time than it takes to describe it and will apply, of course, to a house of any shape or size. It may be added that if the cross-section

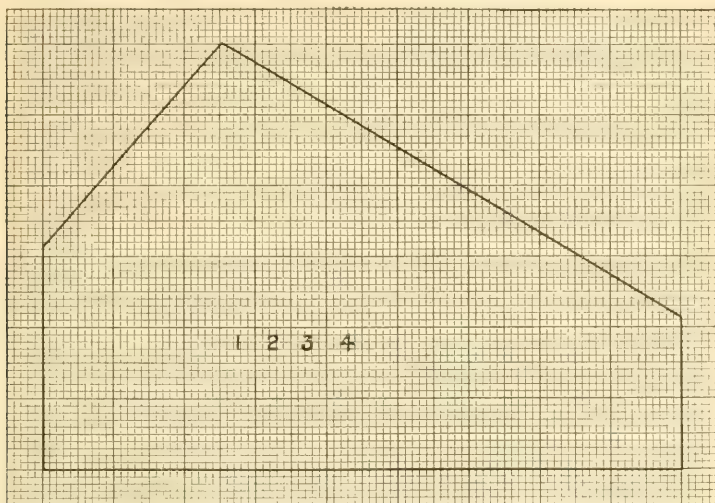


FIG. 5.—Diagram illustrating method of determining cubic contents of greenhouses (after Galloway).

paper can not be obtained readily the sections or squares can be laid off with a rule and lead pencil and practically the same results obtained. In any event, it is only necessary to get an accurate outline drawing of the section of the house, and by projecting this over squares as indicated the number of square feet in the section can be readily determined.

SELECTING A TIME TO FUMIGATE.

Care should be taken to select a night when the houses can be ventilated the required time without injury to the plants and when there is little or no wind.

PREPARATION OF THE HOUSE FOR FUMIGATION.

On account of the very poisonous nature of the gas, it is necessary to arrange a number of ventilators, the more the better, so that they can be easily opened from the outside. It would be very dangerous to enter the house while it contains the gas. All broken glass should be replaced and holes stopped up; a thoroughly wet piece of newspaper will close a crack effectually or take the place of a broken glass if necessary. It is best not to permit the gas to get into fire pits or engine rooms; these should be cut off from the space to be fumigated.

In case of a large range of houses opening into each other it is best to separate them into several sections, by tacking up building paper or oiled cloth, so that each section may be fumigated separately and at different times. The work may thus be done with greater ease and care, and with less danger to the plants. When all the larger cracks and openings have been stopped up, if the house is quite old or loose it is well to wet the roof on the outside just before fumigating. The water will fill the cracks between the glass and will assist in making the roof tight.

METHOD OF MAKING THE GAS.

The materials required are 98 per cent cyanide of potash, best secured in 5 or 10 pound cans at 35 to 40 cents a pound, and commercial sulphuric acid at 3 to 4 cents a pound.

For an ordinary house or frame, good vessels for liberating the gas are $1\frac{1}{2}$ or 2 gallon earthen jars of as small diameter as possible, so as to insure the immersion of the cyanide of potash when it is dropped into the acid. One jar should be used to about every 50 feet in length of such houses as described, in order that the gas may be quickly distributed when set free. When the jars are placed in position the next step is to arrange to lower the paper bags containing the desired amount of cyanide into the jars, from the outside. This is best done by passing a cord through a hook or screw-eye attached to the roof over each jar in such a manner that when the string or strings are loosened from the outside the bags of cyanide will be lowered into their respective jars, as shown in fig. 6. When the strings are ready, divide the amount of cyanide to be used into parts corresponding to the number of jars. Do each part up in a couple of thicknesses of ordinary newspaper and put in ordinary brown paper bags, and attach the bags to the strings, as shown in fig. 6. While the jars are empty test the arrangement to see if it works satisfactorily. After each bag



FIG. 6.—Violet house prepared for fumigation (from Woods & Dorsett).

is suspended in place, the other end of the string securely fastened where it can be reached from the outside, and the arrangement tested, move the suspended bags to one side, so they will be out of the way while putting the water and acid in the jars. When this is done, pour into each jar an amount of water about equal to the bulk of the potassium cyanide in the bag. Eight ounces of cyanide will require about half a pint of water. The sulphuric acid should then be poured in until steam rises from the water. This would require for a pint of water about a pint and a half of acid. It is not necessary, however, to measure the acid, as the evolution of steam indicates when the right amount has been poured in. Always put the water in first and then pour in the acid. As soon as this is done place the bags over their respective jars. In order to prevent injury to foliage in case it is very near the jars, it is a good plan to surround each jar by some protection. A section cut from a roll of building paper is effective. The paper naturally rolls into a tube and is very convenient for this purpose. The pieces may be laid together and tied when not in use,

so that they will keep their shape. When all is ready, go out quickly, close the door, and carefully loosen the strings, allowing the bags to settle into the acid. The gas will very soon be given off and fill every portion of the house. It is colorless and smells and tastes like peach pits. A little of it is harmless, but too much will cause death. A small quantity will leak out of the house; avoid positions where it can be smelled. The time of exposure should be reckoned from the lowering of the cyanide into the jars. When the proper time has elapsed, varying for different plants, as previously stated, quickly open the ventilators from the outside, so that the gas can escape as rapidly as possible. It will all be gone from a large house, such as described in this circular, in half or three-quarters of an hour, and the ventilators can then be closed if necessary. Next morning the material left in the jars should be emptied into a hole and buried. It is nothing but sulphate of potash, sulphuric acid, and water, having a little hydrocyanic-acid gas in solution. The latter will soon disappear, and the sulphuric acid will unite with lime in the soil, forming gypsum.

FUMIGATING BOXES.

For the purpose of experimenting and where only a few hundred plants are to be treated, a tight box may be made of 30 to 50 cubic feet capacity. The box should be as nearly air-tight as possible, with a removable cover and a small door at the bottom for introducing the cyanide of potash into the bowl containing water and sulphuric acid, as shown in fig. 4.

The wire trays as shown in the same illustration are used in fumigating cuttings of coleus or other plants. When desired the trays can be removed and pot plants set in the box and given such fumigation as desired. To prevent injury to the plants they should be so set that the foliage does not come within 18 inches of the bowl near the small door. When the plants are arranged the top is put on securely and a little water is poured into the bowl, and then sulphuric acid is added till steam is formed. The necessary amount of cyanide wrapped in a small piece of newspaper is then dropped into the bowl and the little door quickly closed. When the desired length of time has elapsed take off the cover and open the door and retire, so as not to breathe the gas. In a few minutes the gas will have sufficiently escaped so that the plants may be taken out and others treated in the same way. Injury (if there is any) to the plants may not show for two or three days, so in the case of experimenting, conclusions should not be hastily drawn. The box may be used in the daytime if the work is done in a cool place. For experimental purposes and treating plants on a small scale, a small greenhouse containing 1,000 cubic feet, or less, is better than a box, as the results obtained with it are more reliable, and there is less danger of injury to the foliage.

CONDENSED DIRECTIONS.

- (1) Carefully determine the cubic contents of the house and the amount of cyanide of potash to use.
- (2) Make the house as tight as possible.
- (3) Arrange so that the ventilators can be opened from the outside.
- (4) Place the jars and strings in position.
- (5) After dark attach the bags containing the cyanide to strings, as described, and find if they work correctly.
- (6) Hang the bags to one side and put water and acid into the jars; arrange protection and put the bags in place again.
- (7) When all is ready lower the bags into the jars by loosening the strings from outside.
- (8) After the proper exposure open the ventilators from outside, leaving them open from thirty to forty-five minutes before entering the house.
- (9) Next morning bury contents of the jars.

CAUTION.

It should be remembered that hydrocyanic-acid gas is one of the deadliest poisons known, fatal to human beings and plants as well as to insects.

Greenhouses which are within 50 to 75 feet of dwellings should not be fumigated unless the windows and doors of the latter on the side next to the greenhouse can be closed during the operation.

The bag containing the cyanide should not be permitted to drop into the jar until the operator has left the house.

It is essential that the exact proportion of cyanide be used at the rate designated for each cubic foot of space and that the exposure should not exceed the limit ascertained by experiments as appropriate to the plants to be fumigated. A greater strength of gas or a longer exposure than specified is apt to result in injury to the plants.

It is best to use this method at first experimentally on a small scale before attempting the fumigation of an entire greenhouse, and a preliminary test should always be made in case plants of a species or variety not previously fumigated are to be treated.

Concerning the possibility of hydrocyanic-acid gas forming a deposit upon any of the substances with which it might be brought in contact in its ordinary use as a fumigant, either in greenhouses or in buildings infested by indoor insects, Dr. H. W. Wiley, chemist of the Department of Agriculture, states that there is no possibility whatever of such a contingency, unless the gas comes in contact with some alkaline body, such as soda or potash, with which it would form a salt. The soluble cyanides are extremely poisonous, and if this gas were to act upon lye, or any similar alkaline body, a certain amount of cyanide would be produced. In a dry room, in the absence of alkaline bodies, there could not be any possible danger of a poisonous body being formed.

THE VIOLET SAWFLY.

(*Emphytus canadensis* Kby.)

RECENT INJURY.

October 19, 1897, Mr. Dorsett brought to this office specimens of the larvæ of this sawfly with the information that they were injuring violets in his greenhouses at Garrett Park, Md. He had experienced great trouble with this pest and stated that Mr. Joseph Markle, of Rhinebeck, N. Y., was similarly annoyed by its presence on greenhouse violets. Later Mr. W. G. Saltford, of Poughkeepsie, N. Y., sent specimens of the larvæ to this office, and Mr. B. T. Galloway, of this Department, also submitted for identification another lot of larvæ from Garrett Park, Md. From material received from Mr. Dorsett the adult was reared, and from the bred lot a number of observations on the development of the species were made and will be here recorded.

January 12, 1900, Dr. James Fletcher reported attack by the larvæ of this insect during the previous year in the extensive violet houses of Mr. J. H. Dunlop, of Toronto. He stated also that it was a common pest at Ottawa on pansies and some species of violet.

DESCRIPTION OF THE SPECIES.

The female sawfly may be recognized with the aid of the accompanying illustrations figure 7, *a*, representing the insect with wings expanded and three times the natural size, figure 8, *c*, showing the same with wings folded and natural size, on a violet leaf—and Cresson's translation of Provancher's description (Tr. Am. Ent. Soc., Vol. VIII. p. 38):

"♀.—Length, 0.22 inch; black; head transverse, angular, as broad as the thorax, punctured, with a furrow on each side behind the ocelli; antennæ moderate; palpi, tegulæ, legs, with trochanters and tips of the coxæ, dull yellowish-white; posterior femora except base, tips of their tibiae, with their tarsi, black or deep brown; abdomen entirely black, short and stout; wings hyaline, nervures brown, the costa and stigma deep brown."

The flies reared at Washington differ slightly from the above description, as did those reared by Dr. Dyar, in having the fore and middle tarsi darker toward the apex. Some of the veins and stigma are very dark brown and others are black.

Measurement of the material at hand gives an average of 12.5^{mm} wing expanse and 6.5^{mm} total length of body.

THE EGG AND OVIPOSITION.

The individual fly which issued April 18 was placed in a jar with a potted violet plant, and was soon running about on the leaves with vibrating antennæ and active jaws and ligula, apparently feeding freely and making frequent attempts to insert her ovipositor in the leaves. This she was unable to accomplish with many of the older leaves, nearly all of the eggs found having been inserted in the tenderer leafage. Oviposition and the subsequent escape of the young larva from the place of deposit is not unlike that of the common pear slug, *Eriocampoides limacina* Retz., with the process reversed, the egg being inserted from the upper side of the leaf and the larva escaping on the under surface. The ovipositor is thrust through from above to the lower epidermis, which is left intact, the nidus thus formed with its contained egg appearing as a blister on the lower surface.

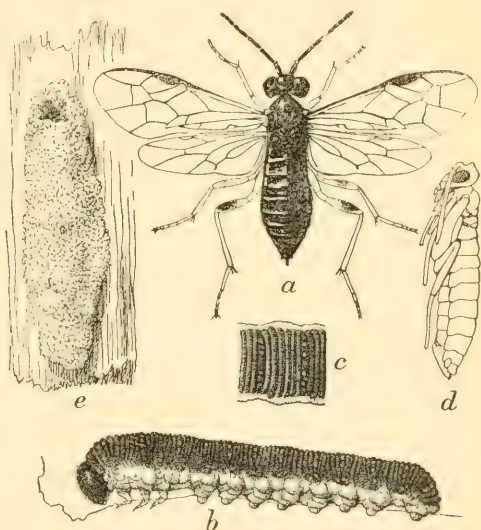


FIG. 7.—*Emphytus canadensis*—*a*, female sawfly; *b*, larva; *c*, abdominal segments of larva from above; *d*, pupa; *e*, cocoon—all except *c* four times enlarged (original).

The egg.—The egg is soft and delicate, and when dissected out appears to be rather variable in shape, but the normal outline seems to be elliptical oval, those deposited on the outer surface being inclined to reniform and narrowed at one end. It is somewhat flattened on its lower surface. Its length is nearly twice the width, the color limpid whitish, surface moderately polished, with no apparent sculpture. Eggs that were measured two or three days after deposition were about 0.7^{mm} in length and a little over half that in width; some, however, were much shorter in proportion to the width. The membrane

of the epidermis protecting the egg on the lower surface of the leaf, although thin, does not permit a good view of the egg within. There is little doubt, however, that the eggs of this species, like those of other sawflies of similar habits, increase in size soon after they are laid, by the absorption of nutriment through their membranous skins from the vegetable juices which surround them.

Eggs are laid singly, but it could not be ascertained whether only one or two are deposited normally on a leaf at one time, although many are often found on a single leaf. These may be deposited by different females or by the same individual on different visits.

In figure 8 the egg cells with the slits made by the female in oviposition are shown on the upper surface of the leaf at *a*, natural size, and much enlarged at *a*¹. The under surface of the cells on the lower surface of the leaf are shown natural size at *b*, and enlarged at *b*¹.

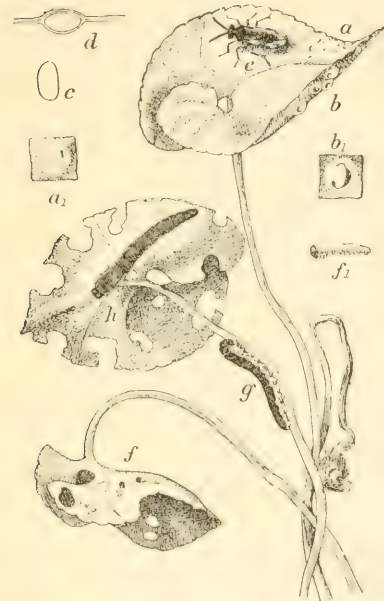


FIG. 8.—*Emphytus canadensis*—Violet leaves showing nature of attack and the following: *a*, egg cells on upper surface of leaf; *a*¹, an egg cell magnified; *b*, cells after escape of larvae; *b*¹, one of same magnified; *c*, egg from above; *d*, egg *in situ* from side; *e*, female at rest on leaf; *f*, newly hatched larvae on leaf; *f*¹, same enlarged; *g*, active stage of larva; *h*, full-grown larva feeding. *a*, *b*, *c*, *d*, *f*, *h*, natural size; *a*¹, *b*¹, *e*, *d*, *f*¹, more enlarged (original).

These illustrate the method of escape of the young larva from the egg. The egg is shown much enlarged in outline at *c* and in section *in situ* at *d*.

DESCRIPTIONS OF THE LARVA AND PUPA.

The loss of the material under observation through failure of the eggs to hatch prevented detailed descriptions of the various stages.

The newly-hatched larva.—The larva when first hatched presents the appearance shown in figure 8. At *f* is shown at the right a larva

natural size crawling on a leaf, and, at the left, one in the curled-up position which it assumes when disturbed. At f^1 it is shown, lateral view, enlarged; the color is light slaty, and the head, it will be seen, is proportionately larger and the legs longer than in its more mature stage; its length is about 2.5^{mm}. At g of the same figure, the penultimate stage, which appears to be the most active, is shown from the side resting quietly on a leaf stalk.

The full-grown larva.—A mature larva is illustrated at h of figure 8, feeding upon the under surface of an injured violet leaf. It is here represented in its largest state. After ceasing to feed it begins to contract, and assumes more of the appearance of figure 7, b , which represents the larva in its most characteristic form. The general color of the larva, as it approaches maturity, is dark dull olive or slate above with a bluish tinge. It is rather conspicuously marked with minute white tubercular spots, arranged in transverse rows of four dorsal and two lateral on each side, as shown in the illustrations, but these disappear in the contracted final stage and can hardly be detected in preserved specimens. The ventral surface is pale-gray, also with a bluish tinge.

The length of the mature larva as it lies extended on a leaf just before the last molt previous to the final prepupal stage is about 15^{mm}. When fully extended it measures 18^{mm}, and in its contracted state just prior to pupation it is only about 8.5^{mm} in length.

A larva that came under observation May 6 will well illustrate the changes of color just prior to and after molting. Immediately before this molt, which occurred at 11.15 a. m., the general color of the dorsal surface had become very dark, nearly black; a few minutes after molting it was very light, nearly uniform leaden gray, the ventral surface but slightly lighter, the head being now light pearl gray, with the black eyes showing prominently. When next seen, about five hours later, the general color had turned to glaucous blue. Next morning, when this larva was again examined, the color had not changed appreciably, except that it was a little darker and duller. The color undergoes but little change from this time till the contracted stage is assumed.

Dr. Dyar's technical description of the mature larva is appended:

Head rounded, normal, dull black, slightly slaty; eye and mouth black, the sutures around clypeus pale; some short pale hairs; width, 1.4^{mm}. Body of nearly equal width, slightly largest at anterior end; thoracic feet small, abdominal ones well developed, present on joints 6 to 13 (22 feet). Segments 6-annulate, rather sharply so, and about as distinct as the segmental incisures. Color slaty black dorsally, not shining, smooth, the dorsal vessel showing darker; below the spiracles olive gray. Thoracic feet pale. On each segment, on second annulet, a transverse row of minute white points, with a second one on first annulet stigmatically; a few less conspicuous ones on subventral ridge.

Final stage.—Head blackish above, pale below; eye in a black spot; mouth brown; antennæ and palpi pointed, minutely brown-ringed; width, 1.4^{mm}. Body entirely dark olive-gray, rather bluish, slaty, the segments neatly 6-annulate, not shining, evenly minutely granular. Feet transparent, spiracles in paler areas. No white points or tubercles.

The pupa.—The pupa is sufficiently shown at figure 7, *d*. It measures about 7.5^{mm} in length and is nearly white in color, the eyes turning darker as it approaches the time for final transformation.

The change to pupa in the confinement of our rearing jars took place in the pith of sunflower stems placed there for the purpose. A cocoon is shown at figure 7, *e*.

DISTRIBUTION.

Little can at present be said of the distribution of this species. Like the majority of sawflies, it is most abundant in the North, but has undoubtedly been disseminated by commerce in shipments of violets and pansies from one place to another. Its occurrence has not been noted out-of-doors in the vicinity of the District of Columbia to the writer's knowledge, and it would therefore seem probable that it is a comparatively recent introduction, if we may use the term in speaking of a native species being established in new localities. The known distribution embraces Plattsburg, Rhinebeck, and Poughkeepsie, N. Y.; Garrett Park, Md., Toronto and Ottawa, Canada.

It is not a little singular that a northern species of insect as this seems certainly to be should become acclimatized in greenhouses as far south as the District, since it is a well-established fact that a very large proportion of the insects that lead an indoor life are of tropical origin.

HISTORY OF THE SPECIES.

This species was first described in the year 1878 by the Abbé L. Provancher as *Enophytus pallipes*, a name preoccupied by Spinola for a European species of this genus. Kirby's description of *E. canadensis* appeared in 1882 (List Hymen. Brit. Mus., Vol. I. p. 204). There are several accounts bearing on the biology of this species. One is by Dr. H. G. Dyar, of the U. S. National Museum, published in 1894 in the Canadian Entomologist, in which he describes the larva in the last two stages and gives some brief notes on its habits and occurrence on cultivated pansies at Plattsburg, N. Y. In the Florists' Exchange for August 7, 1897, Mr. B. T. Galloway published a short article on this insect under the title of "Injury to Violet plants," the species being identified as "an undetermined sawfly." Brief mention is made of the larva and its manner of work, the article being devoted mainly to methods of control. The nature of injury by the larva is illustrated. This article was republished in American Gardening for August 21 of the same year. In Fauna Ottawaensis Hymenoptera Phytophagica, an article by Mr. W. H. Harrington, published in volume VII, Ottawa Naturalist, and consisting of a list of the Phytophagic Hymenoptera taken in the neighborhood of Ottawa, Canada, the following appears concerning this species: "Eight females. May 8, June 9. Violets and pansies."

In his annual report as Dominion entomologist of Canada for 1898 (p. 169), Dr. Fletcher briefly mentions considerable injury that was done in beds of violets at Toronto, Ontario, reported to him by Mr. J. Dunlop, a florist of that city. He states that complaints of this false caterpillar have occasionally been noticed in the past to foliage of pansies (*Viola tricolor*, varieties), but that no great injury had previously been recorded.

Brief notice of Mr. Pratt's rearing of this species in 1899 from violets received from Rhinebeck, N. Y., was recorded in the proceedings of the Entomological Society of Washington (Vol. IV, p. 302).

During the fall of 1899 Mr. Galloway published in his book entitled "Commercial Violet Culture" a short account of this insect, without, however, mentioning the species scientifically.

The same year Dr. Fletcher again mentioned this species somewhat briefly in connection with injury to pansies and violets at Toronto, Canada (Transactions Royal Society of Canada, Vol. V, second series, 1899-1900, p. 228).

BIBLIOGRAPHICAL LIST.

The bibliography of this species is moderately extensive. A list of articles arranged in order of publication is appended for convenience of reference:

- L. PROVANCHER, *Naturaliste Canadien*, vol. X, p. 66, 1878.
 E. T. CRESSON, *Trans. Amer. Entom. Soc.*, vol. VIII, p. 38, 1880.
 W. F. KIRBY, *List Hymen. Brit. Mus.*, vol. L, p. 204, n. 49, 1882.
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 W. H. HARRINGTON, *Ottawa Naturalist*, vol. VII, p. 122, Nov., 1893.
 H. G. DYAR, *Canadian Entomologist*, vol. XXVI, p. 185-6, 1894.
 B. T. GALLOWAY, *Florists' Exchange*, vol. IX, p. 720, Aug. 7, 1897; *Am. Gardening*, vol. XVIII, p. 585, Aug. 21, 1897.
 JAMES FLETCHER, *Rept. Entom. & Bot. Expt. Farms Dom. Canada for 1898*, p. 169, 1899.
 [F. C. PRATT]. *Proc. Entom. Soc. Wash.*, vol. IV, p. 302, 1899.
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 JAMES FLETCHER, *Trans. Roy. Soc. Canada*, vol. V, 2nd ser., 1899-'00, p. 228.

MANNER OF WORK—HABITS OF THE LARVÆ.

The larvæ, while very young, feed on all parts of a leaf by cutting out little holes from the lower surface, and later, when more mature, eating along the edge of the leaf. Occasionally, at least, they nibble the flower stalk and destroy the flower, as shown in the illustration (fig. 8). An idea of their injuriousness may be had when it is said that the potted plant on which the larvæ were first kept began to wither and die during the third week of April, necessitating the removal of as many large larvæ as could be found to prevent the entire destruction of the plant. The second plant was injured in like manner, and the next two or three colonies completely stripped the first

plant of leaves. A third plant was also defoliated. In a few instances larvæ attacked the stems, in one case eating them off nearly to the roots.

Injury by the larger larvæ is much worse, the younger ones appearing to confine attack to cutting small holes here and there in the leaf.

The punctures made by the females in oviposition and the holes made by the larvæ in escaping from the nidus in the leaf also cause injury, particularly when the eggs are deposited in a bunch, as shown in the illustration (fig. 8, *a, b*). The tip of the leaf withered and nearly died as a result of this attack.

The younger larvæ have the habit of resting during the daytime, usually in a curved position like the letter J. When disturbed even slightly, they promptly curl up spirally, after the manner of many Tenthredinids, and drop from the plants to the earth below. All of the youngest larvæ that have come under observation rest thus on the lower surface of the leaves, and are never curled spirally when upon the leaf. The more mature larvæ may be found during the daytime extended lengthwise on the leaves and more particularly along the stems near the ground, but sometimes in other positions, with their heads usually pointed upward but often downward. In this position they are afforded sufficient concealment on fresh plants to readily escape notice. On such plants, except when occurring in great numbers, they are eminently successful in eluding observation at nearly any time. For example, only one or two of the nearly grown larvæ in a lot of upward of a dozen on a small plant were to be seen at one time, the others being securely hidden from view.

Of the first two broods reared—using the word not in the same sense as generation, but as the progeny of one female—it was quite noticeable that the larvæ did not in any case desert the plant on which they had hatched until they were mature or very nearly so.

Injury is most apparent late in May and early in June, and almost entirely to plants grown under glass, being particularly noticeable, upon plants growing in shaded locations, such as are to be found in greenhouses, under gutters, where the plants grow ranker. In some cases injury appears to be confined to such locations. In the greenhouse, according to Mr. Galloway, "seldom more than two of the worms are found at one time on the same plant. Two, however, are enough, as they will riddle a half-grown plant in a week."

Mr. Dorsett's experience with this species goes to show that it is quite persistent in the greenhouse, and difficult to dislodge after it has obtained a foothold, in this respect ranking with several other species, such as the "red spider" and the aphides, which are not, like the sawfly, limited to any one genus of host plants. In spite of frequent and systematic fumigation and careful watchfulness in his greenhouse, this species continues to be seen, although in small num-

bers, at intervals every year. This is the more remarkable in that the species has practically become an indoor one so far as we know, and the individuals found from time to time are therefore evidently survivors of the original lot first introduced in a previous year.

The length of life of the mature sawfly is only a matter of three or four days. It was noticed of the adults that were transferred to new quarters for oviposition, when first issued, that they died in this time. One that was found just casting off its last pupal skin June 10 was isolated on a potted violet on the 11th, was observed living as late as noon of June 13, and was found dead and dry on the morning of the 15th. It had evidently lived an active life of only three or four days.

PARTHENOGENESIS.

The material received in October, 1897, was taken in charge by Mr. Pratt and confined with potted violets, surrounded by a glass cylinder, resting upon a base containing sand, which was kept moderately moist, as the plants did not require a very great degree of moisture. Upon this sand there was placed a stem of sunflower, containing pith, and in this the larvæ constructed their cocoons. The first adult was observed March 17, 1898, its appearance being nearly coincident with the blooming of its host plant: a second and third appeared about April 7, a fourth April 18, and a fifth was found May 2. All of the imagoes reared were females.

April 7 the writer noticed young sawfly larvæ feeding on the leaves of the plants used in these observations. This was prior to the appearance of any except the first issuing adult, and is proof conclusive of parthenogenesis in this species—a not unusual occurrence in Tenthredinidæ, but more commonly met with in certain other families of Hymenoptera, and particularly well known in Cynipidæ.¹

April 16 at least two new broods of the larvæ were observed, the progeny of the females that were found dead April 9, and yet another brood was obtained from the female which issued late in April, furnishing still further evidence of parthenogenesis.

All of the flies reared in May and June were females. A portion were placed with two pots of violets, but not carefully watched, as it was not deemed necessary to do so with this generation, it being the intention merely to note from the time of first egg-laying to the issuance of the first fly of the next generation, and then to follow this last closely, to obtain all stages of the midsummer generation. Only a few larvæ hatched, and it was then found that the plants were dying from

¹Parthenogenesis in the Tenthredinid genus *Emphytus* has been recognized by the distinguished zoologist, C. Th. E. von Siebold. In *Entomologische Nachrichten* (Vol. X, p. 95), published in 1884, he records the fact that eggs laid by virgin females produced males in the European species *Emphytus cinctus* L. and *E. viennensis* Schr.

“red spider” attack. It is almost certain that this same red spider had killed the sawfly eggs or at least prevented their development.

DEVELOPMENT.

The first of the larval offspring of the female found March 17 attained mature growth and deserted the plant on which it had fed May 3. In the absence of more accurate information we may assume that this female issued about March 14, and that eggs were deposited during the next three days. It may be assumed also that the egg stage was at this season about eighteen days, which would leave an active larval period of about four and a half weeks.

From eggs that were deposited by a fly which was confined alone with a violet plant April 19, the first larva hatched May 1, giving as the duration of the egg state for this period, which was colder than normal, twelve days.

From May 4 until about the 10th or later the other larvæ of this brood, about a dozen in number, deserted the plant and crawled about on the glass cylinder confining them.

May 25 the first fly of this brood was found to have issued, having passed the entire cycle from egg to imago in about ten weeks.

The first larval molts of the first spring generation were not observed. A number of mature larvæ were isolated and observations made from the time of the penultimate molt to the issuance of the adult.

No. 1 molted April 21 and afterwards, and transformed to pupa May 25.

No. 2 molted April 22, also afterwards, and transformed to pupa May 26.

Nos. 3 and 4 molted May 10, and had assumed the contracted form by May 21. May 25 both transformed to pupa, and to imago May 31.

No. 5 molted May 6, began May 9 to bore into the pith of a stem supplied for the purpose of pupation, and in the course of an hour had obtained entrance and closed the aperture with the comminuted bits of pith produced by its boring. May 14 a portion of pith was removed that further transformation might be observed. Pupation ensued May 25 and the adult appeared June 1. The last fly observed issued June 11.

These periods, if so we may term them for present convenience, are of course variable according to atmospheric conditions—heat or cold, humidity or dryness—and are probably also subject to individual variation in the larval stage. Approximately, we may say that the penultimate larval molt in the first spring brood takes place about five weeks from the time of pupation, the final larval molt occurring about eighteen or twenty days later than this. The duration of the final contracted larval stage could not definitely be determined, as it is gradual and hence it is difficult, if not impossible, to determine where

the penultimate larval stage ends and the final stage begins. Of this, however, we are certain, that there is an inactive period, or at least what we may consider such, although neither larva nor pupa is truly quiescent, of at least two weeks during which the larva remains in its pupal cell.

The entire cycle from the date of laying of the eggs to the issuance of the first adult was between eight and ten weeks.

From the above data the approximate life cycle for the first spring generation may be deduced as follows:

	Days.
Egg period, from laying to hatching	12-18
Active, feeding stage of larva.....	24-31
Inactive or nonfeeding larval stage.....	14
Pupal stage	6- 7
Entire life cycle.....	56-70

NATURAL ENEMIES.

As only a single lot of this species was used in rearing, no parasites were developed. In one instance, however, an adult fly, not yet mature, was found to have succumbed to mites and it has already been stated that eggs were destroyed by red spiders. No larvæ died as far as noticed, although the first generation was exposed to a temperature which was below freezing out-of-doors and not much higher in the rearing jar, which stood near an open window in an unheated room.

REMEDIES.

The violet sawfly is amenable to the same remedies that have been found most useful against the greenhouse leaf-tyer in greenhouses. Hand-picking of the larvæ has been employed with some success by Mr. Dorsett and others, but is too slow to be entirely satisfactory and the larvæ are difficult to discover. Extract of tobacco diluted at the rate of 1 part extract to 30 parts of water was also effective when applied as a spray, but florists are opposed to the use of tobacco on violets owing to its tendency to weaken the plants and to bring on the condition known as "spot." Where the hydrocyanic-acid-gas treatment has been carefully followed, this species has been prevented from doing appreciable injury.

THE TWO-SPOTTED RED SPIDER.

(*Tetranychus bimaculatus* Harvey.)

Perhaps the most troublesome of greenhouse pests, everything considered, are minute reddish spider-like creatures known popularly as "red spiders." They often do very considerable damage in flower and vegetable gardens, but in greenhouses they attain their greatest destructiveness, and are particularly injurious to violets and roses, as well as to a great variety of other plants.

Until within the year 1900 the common red spider most often occurring in greenhouses was technically designated as *Tetranychus telarius* Linn., a name which has been rather indiscriminately applied to all species of red spiders, both in America and abroad.

Red spiders are not true insects, in fact not even spiders, but are, more properly speaking, spinning mites. Since, however, they are almost universally known as red spiders, this term is retained for present purposes.

As the word "mite" indicates, these insects are extremely minute, and when they occur in ordinary numbers are not apt to be noticed unless leaves are carefully scrutinized. Attention, however, is certain to be drawn to them when they become excessively numerous, as frequently happens in neglected greenhouses or out of doors during droughts in summer.

Red spiders spin threads, but do not, like true spiders, utilize them for climbing or descending from a height. The threads spun are extremely fine and scarcely perceptible to the unaided eye, but a web of threads is frequently so dense as to form a tissue plainly visible at a little distance. Webs are usually constructed

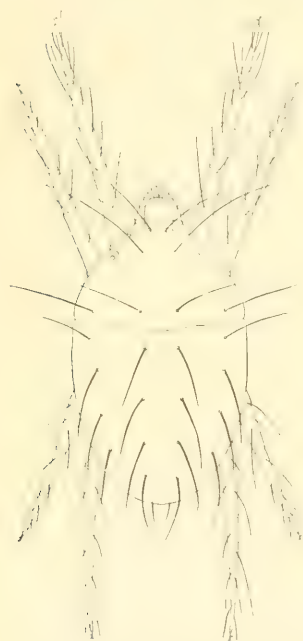


FIG. 9.—*Tetranychus bimaculatus*: adult—enlarged (from Banks).



FIG. 10.—*Tetranychus bimaculatus*: palpus—enlarged (from Banks).



FIG. 11.—*Tetranychus bimaculatus*: claws—enlarged (from Banks).

upon the lower sides of leaves, and attached here and there to projecting hairs, veins, or the edges of the leaves. Within the webs thus formed the mites feed in their different stages, and the eggs are laid from which the young develop.

The general appearance of the red spider under consideration, which is now known as *Tetranychus bimaculatus* Harv. as it looked under a microscope, is well shown in figure 9. At figure 10 a greatly enlarged palpus of the same species is illustrated, and figure 11 shows the claws similarly enlarged.

The length of full-grown individuals, including the palpus, is from 0.4 to 0.6 mm and the width 0.25 to 0.30 mm, the thickness being 0.17

to 0.20^{mm}. The form is broadly oval, the width greatest in the anterior third of the body, back of the eyes, where the sides are somewhat distended. The general color of the adults is reddish, usually more or less tinged with yellowish or orange, and most specimens have a dark spot on each side, due to the food contents of the body, from which the scientific name *bimaculatus* (two-spotted) has been derived.

Careful study of different individuals as they occur on garden vegetables and horticultural and other plants grown out of doors with those taken in greenhouses shows no appreciable differences. According to Mr. Banks, however, specimens taken in Florida on *Datura* and at Washington, D. C., on violets are red, while those from Orono, Me., and those from the District of Columbia on squash and peaches, and those on rose from Idaho, are greenish with more or less dark markings.

The eggs are extremely minute, spherical, of variable diameter, glassy, and are scattered and loosely attached about the webs.

The young are of somewhat similar appearance to the adults, but differ in having only three pairs of legs.

DISTRIBUTION.

If, as seems probable, *Tetranychus cucumeris* or some other species described by Boisduval (Entom. Horticole) is identical with the present species of red spider, it is quite likely that it is of foreign origin and introduced into the United States, which is true of a very large proportion of greenhouse and other indoor insects.

The two-spotted red spider is well distributed through the eastern United States, and has been identified as occurring in localities as far west as Idaho. A list of localities from which the species has been reported includes Orono, Me.; Ithaca and New York City, N. Y.; Westgrove, Pa.; Washington, D. C.; Tremont, Pekin, and Bloomington, Ill.; Punta Gorda, Key Largo, Galloway, and Eustis, Fla.; Charleston, S. C.; Auburn, Ala.; and Weiser, Idaho.

RECENT INJURIES.

During the past two years we have received complaints of this species from various sources, as follows:

June 9, 1899, from Mr. H. M. Simons, who reported its occurrence on snap beans grown at Charleston, S. C. The species was stated to have literally overrun and totally destroyed the beans where discovered. It had not been seen in previous years, and it was noticed that the season had been very dry.

July 6 the occurrence of this red spider was reported by Mr. F. S. Earle on cowpea and beans at Auburn, Ala.

May 8, 1900, it was concerned in injury to raspberry at Bloomington, Ill., and reported to this office by Mr. J. L. Lampe, jr.

August 2, 1900, its occurrence on *Apios tuberosa* was reported by the late Thomas A. Williams, of this Department.

Violets and carnations were seriously injured during the last two years in the District of Columbia, and we received in a letter dated March 19, 1901, information concerning general destructiveness by this species to strawberry in the vicinity to Galloway, Polk County, Fla. Our correspondent, Mr. E. G. Gardner, stated that the mites were always found on the underside of the leaves.

IDENTITY OF THE SPECIES; LITERATURE.

The subject of the specific identifications of the different species of red spiders which occur in this country, of which there are 11 distinct forms described, together with the characteristics which distinguish them, and other information of more or less technical import, has been already made public in a paper entitled "The Red Spiders of the United States," by Mr. Nathan Banks, published on pages 65-77 of Technical Series No. 8 of this Division.

Tetranychus bimaculatus was first described by the late Prof. F. L. Harvey in 1893 (Annual Report Maine State College Agr. Exp. Station, Part IV, pp. 133-144, pl. 3). This account includes valuable notes on the insect's habits and injuries, a tabulated list of host plants, extracts from correspondence, and a consideration of remedies, besides technical descriptions of the different stages of the species.

In Galloway's Commercial Violet Culture, already quoted, considerable space is devoted to a consideration of this species, mentioned as "red-spider" (pp. 190-198), particular attention being given to remedial treatment based upon years of experience with it as it occurs on violets grown under glass.

The above-mentioned publications have been freely used in the preparation of the present article.

The species has been treated from the standpoint of an enemy of sugar beets, with brief mention of its occurrence on hemp near Tremont and Pekin, Ill., in 1899 and 1900, on pages 406 and 407 of Bulletin No. 60 of the University of Illinois Agricultural Experiment Station, by Messrs. Forbes and Hart.

FOOD PLANTS AND NATURE OF INJURY.

The two-spotted red spider is inclined to be omnivorous, attacking a wide range of both glabrous and hirsute plants belonging to several families. It is present in greenhouses throughout the year, and appears to be able at all times to be destructive if permitted to propagate. Few plants are, in fact, free from the attack of this red spider, and it is present in most greenhouses. When only a few mites are present, the plants seldom show any external evidences of injury, but as they

increase in number the leaves gradually turn paler and yellowish in color and become stunted, and soon the whole plant succumbs unless the proper remedies are applied. Cuttings or young rooted plants are particularly subject to serious injury, and this is especially true in the spring. At this time the mites multiply rapidly, and unless plants are carefully watched they are apt to become so badly infested that it is only with extreme difficulty that they can be restored to their normal growing condition.

The mites injure the plants by suction, and when they occur in numbers, which they almost assuredly will do when plants are neglected, the vitality of the plants is slowly but surely reduced by the loss of their juices, and in time all of their functions are more or less deranged.

In cases of severe attack, millions of red spiders can be found upon the foliage of plants, and the webs, which are rarely observable at ordinary times, sometimes stretch from plant to plant, and the mites may be seen passing rapidly over them and congregating in swarms.

The following list of food plants has been compiled from Professor Harvey's article previously mentioned (l. c., p. 142): Clematis, mignonette, pink, Indian mallow (*Abutilon* spp.). Pelargonium, Canary bird (*Tropæolum peregrinum*), beans, rose, apricot, Cuphea, Godelia, Fuchsia, Passiflora, cucumber, muskmelon, Manettia, Bouvardia, feverfew, Mimulus, slipper flower (*Calecolaria* spp.), Thunbergia, verbena, sage, heliotrope, cypress-vine, moon-flower, morning glory, tomato, pepino (*Solanum muricatum*), eggplant, pepper, wedding bell (*Brugmansia arborea*), castor oil plant, hop, calla, Boston smilax, and Easter lily.

Violets and roses are particularly troubled by this species of red spider, more especially, as might readily be inferred from what has already been said, when these plants are grown under glass. Peaches have been injured by the curling of their leaves; squash, corn, cowpea, raspberry, *Apios tuberosa*, strawberry, beets, hemp, and watermelon have also been reported to be attacked.

REMEDIES.

Red spiders are resistant to fumigation either with tobacco or hydrocyanic-acid gas, and only a portion of these creatures are usually killed by the ordinary use of the gas in greenhouses. They are stupefied for a time, but eventually recover. They are, however, extremely sensitive to sulphur, applied either dry or as a wash or in connection with other poisons, and to soap.

Flowers of sulphur, mixed with water at the rate of an ounce to a gallon and sprayed over infested plants, is of great value in the eradication of this pest; or the sulphur may be combined with a strong soapsuds. For the application of this spray a force pump with spraying nozzle is of course a necessity.

Kerosene emulsion and whale-oil and other soap solutions are also valuable, and the addition of the sulphur increases their effectiveness; but these washes are too strong for some plants and are apt to injure them.

For the particular red spider in question, as it occurs in greenhouses, particularly on plants that are liable to injury by the use of sulphur, such as violets, no other remedy is used by florists generally than frequent syringing or spraying with water or with a solution of neutral soap. Both have been extensively used by Mr. Galloway in growing violets, from whose experience the following instructions have been gathered:

Neutral soaps, such as castile soaps, are particularly valuable for use upon cuttings affected with red spider, and the best results have been obtained in using such at the rate of a 5-cent cake to 6 or 7 gallons of water. The soap is shaved with a small plane, dissolved in about a gallon of hot water, and then sufficient cold water is added to make the quantity desired. Five gallons are sufficient for the treatment of three or four cuttings of violets, and other plants are in proportion. It is customary to allow the soap to remain on the plants two or three hours, and then thoroughly syringe with clear water, repeating this treatment two or three times until the spiders and their eggs have been destroyed. Used in this way, the soap has little if any deleterious effect upon most greenhouse plants.

It is unsafe to use strong soaps, such as potash, whale-oil, or fish-oil soaps, as they are apt to injure delicate plants and are of no more value as insecticides than those of a neutral nature.

Tobacco water is of some use for the same purpose, but can not be recommended for violets owing to the tendency which tobacco has to weaken the foliage and induce "spot."

Spraying with water is usually practiced from two to three times a week during the growing season, and by a little practice and experiment with a fine spray nozzle or tip the operator will soon be able to ascertain the proper degree of force to use. A pressure of about 25 pounds has proved most effective against this red spider. Care should be exercised to wash off the spiders and at the same time not to drench the beds. When it is necessary to spray during the winter time work should be done on a bright day in order that the plants may dry off in a few hours.

Spraying apparatus.—For several years the want has been felt by florists of a spraying apparatus that would be perfectly satisfactory for use in greenhouses, and that could be purchased at a moderate price. Such a sprayer has been devised by Mr. Galloway, and the illustration here presented (fig. 12) shows its general appearance. It will be seen that it is an ordinary hand syringe fitted with a Vermorel nozzle and provided with a separate intake attachment.

To change the syringe to a sprayer a cap (fig. 13, *c*) with a larger opening is put on in place of the usual one, and into it is screwed the Vermorel nozzle. The nozzle proper (fig. 13, *n*) necessarily has a very small orifice, and to fill the syringe through this would require too much time; hence a larger opening is made (fig. 13, *o*), and into this a ball valve is fitted (fig. 13, *b*). This latter is so arranged that when the handle of the syringe is drawn up the liquid is drawn in through the opening, and when forced down the ball valve closes the intake and the liquid issues from the nozzle in the form of a mist-like spray.



FIG. 12.—Hand sprayer, complete (from Galloway).

This syringe, with its attachments, will be found valuable also for whitewashing benches, shading glass, and other purposes. The syringe under consideration was devised for the application of fungicides, but it may be used for insecticides also and for the application of water to plants; but for the syringing of plants with water, where this is

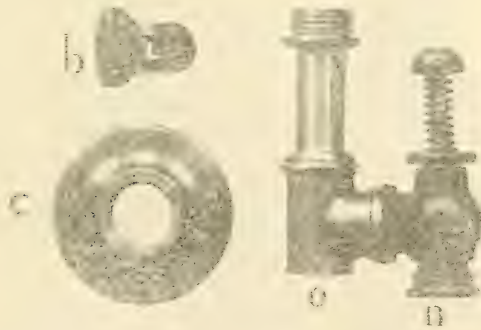


FIG. 13.—Parts of hand sprayer: *c*, cap; *n*, nozzle; *o*, opening closed by ball valve; *b*, ball valve (from Galloway).

practiced on a large scale, still another apparatus has been devised in the shape of a tip and nozzle of the form illustrated in figure 14. The nozzle consists of a casting turned to the desired length and flattened at the end, as shown. Through the flattened end a narrow slit is made, and it is important that the slit or opening be absolutely true

throughout, so that the water, when it issues, will be broken up into streams. It will sometimes be found necessary to file the tips as they come from the factory to produce the desired results.

The spray tip proper is attached to a brass fitting, which in turn screws onto the end of a three-quarter-inch hose. The apparatus is very effective for spraying roses, as it readily serves to keep the leaves in a thoroughly healthy condition, and at the same time wets the beds but little. It is also very useful for violets, as with a pressure of 35 to 40 pounds the leaves of the plant can be readily turned over and thoroughly washed without soaking the crowns and the bed. In spraying some plants, particularly violets, it has been found advantageous to use a lance 18 inches long, made of a piece of one-half-inch brass pipe. This increases the reach, and enables the operator to place the water to better advantage on plants which under ordinary



FIG. 14.—Tip and greenhouse nozzle, complete (from Galloway).

conditions would be beyond arm's length. The apparatus can be made for 50 cents, and will be found a useful instrument wherever there is sufficient water pressure to insure a proper amount of force. (Circ. 17, Division of Vegetable Physiology and Pathology.)

THE BLACK OR BROWN APHIS OF VIOLETS.

(*Rhopalosiphum viola* Perg.)

Until within five or six years from the present time one of the most troublesome insects upon greenhouse violets in the vicinity of the District of Columbia, as well as elsewhere, was a plant-louse known to florists as the "green fly" or "green aphis." Some time in the spring of



VIOLETS SHOWING INJURY BY PLANT-LICE.

1893 (or '4) Messrs. Galloway and Dorsett, at that time jointly concerned in the propagation of violets at Garrett Park, Md., noticed for the first time a darker species of plant-louse in their greenhouses, which in time practically displaced the other form and has become the most injurious violet pest of this vicinity and in other localities where it has been introduced. The matter was not immediately brought to the attention of any specialist in the Aphididae and the species was not identified until recently, even generically. What is with little doubt the same insect is now known to be widely distributed in our violet-growing regions, being generally recognized by the trade under the rather inappropriate name of "black aphid" or "black fly," by which cognomens it has received mention in recent years in various floral journals. Regarding its rank as a pest, Mr. George Saltford, a prominent violet grower of Rhinebeck, N. Y., says: "It is the greatest scourge of the violet grower to-day." (The Florists' Exchange for December 10, 1898.)

NATURE OF INJURY.

These plant-lice are to be found in greatest numbers at the crown of the violet plant, in the petioles and on the under side of the leaves, and they accomplish considerable injury by entering the young opening buds and inserting their haustella, or sucking tubes, through the overlapping petals. When the petals unfold they are seen to be distorted and bleached where they have been injured, these spots showing greenish-white, and in some cases almost pure white. The flowers also are dwarfed and distorted, the stems are nearly always shorter than is normal, and the flowers altogether present a weak, sickly, and unsightly appearance when contrasted with healthy blooms. Injury is apt to be very disastrous unless the aphides are destroyed in some manner. In the accompanying illustration (Plate II) normal violets are shown below, and a small bunch of flowers injured by this aphid are illustrated above.

This species of aphid has not been under continued observation, and hence we have no very full notes regarding its development. Winged forms were noticed in March, April, and May, and again during the first two weeks of November.

DESCRIPTIVE.

As the species was apparently undescribed, a description was drawn up by Mr. Th. Pergande and published in the Canadian Entomologist of February, 1900 (Vol. XXXII, pp. 29, 30). The grower of violets will readily distinguish this from the green aphides which affect his plants, with the aid of the accompanying illustration (fig. 15). The winged female, shown at *a*, is of attractive appearance. She has a dark cherry or purplish brown body, clear wings with the veins strongly and con-

spicuously clouded with dull black, as figured. The tail is short and inconspicuous; the nectaries are clavate, reaching to the tip of the abdomen. The species is somewhat remarkable on account of the inconstancy of the wing venation. Certain of the terminal veins are often wanting, as illustrated at *b*. The apterous or wingless female, shown at *c*, and the last stage of the nymph, (*d*), are of similar general color to the winged form, but usually paler.

The length of the body and head together is about $\frac{1}{3}$ of an inch (nearly 2^{mm}) and the wing expanse about $\frac{1}{4}$ of an inch (5-6^{mm}).

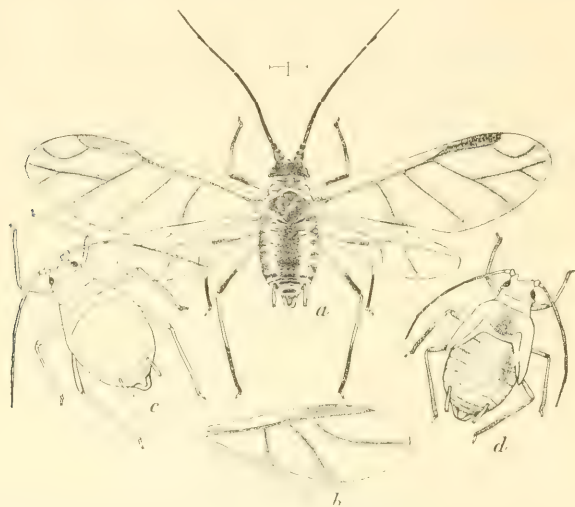


FIG. 15.—*Rhopalosiphum violae*: *a*, winged female; *b*, wing of same, showing aberrant venation; *c*, wingless (agamie) female; *d*, nymph—all much enlarged (original).

DISTRIBUTION.

This plant-louse is of doubtful nativity. The fact that it appears to confine its attack to plants grown indoors would indicate a tropical and therefore foreign origin; but as the species has been described from this country, and is not known elsewhere, it will have to be considered native until we learn to the contrary. The present distribution includes the following localities, the list being necessarily small on account of the newness of this insect as a pest: Toronto, Canada; Poughkeepsie, Rochester, and Cornwall-on-Hudson, N. Y.; Newton Center, Mass.; Providence, R. I.; Garrett Park, Waverly, Brooklyn, and elsewhere in Maryland; District of Columbia; Gordonsville, Va.

DIVISIONAL RECORDS OF INJURY.

In August, 1898, Mr. Dorsett visited Mr. Theodore Diedrich at Anacostia, D. C., and ascertained from that gentleman that this species had done immense injury to violet blossoms, the cash estimate of his losses being placed at \$1,000 to \$1,200 for that year.

During the following autumn correspondence was received from Mrs. J. Sampson, Gordonsville, Va., regarding the occurrence of this species in her violet beds, this being the most troublesome violet pest in that locality.

November 19 of the same year Mr. W. D. Philbrick, Newton Center, Mass., wrote that this species, specimens of which were received, was present in his violet beds, and that they are usually noticed to be quite plentiful when the plants are first brought in under glass in the fall from the field where they are grown in the summer. This species, he reports, is most abundant on the petals of the flowers.

The following day Messrs. Thomas De Voy & Son, Poughkeepsie, N. Y., sent specimens with the information that these insects appeared in their violet houses during the summer of 1897, and that they were introduced through the purchase of plants from elsewhere. They gave considerable trouble that season, and the following year they occurred in vast numbers. Of their occurrence our correspondents wrote:

The increase of these terrible pests is not owing to neglect on our part; we have fought them constantly from propagating beds down to the present time, using tobacco smoke, soap water, and tobacco dust. These remedies hold them in check somewhat if constantly applied, but the insects appear to breed by the million in a single warm day or night. Several of the growers in this vicinity are troubled like ourselves with this pest, and it is beginning to alarm us, for it seems impossible to eradicate them from houses once infested.

December 12 Mr. John G. Bahret, Poughkeepsie, N. Y., sent specimens obtained from a neighboring greenhouse. His own greenhouse was free of the pest, but he had heard much talk concerning its great damage in his vicinity. The cold weather at the time of writing appeared to have had considerable effect upon the little pests, as they were not found in abundance.

February 27, 1899, Mr. W. V. V. Powers, Cornwall-on-Hudson, N. Y., sent specimens of the adult, taken on hothouse violets at that place.

No further complaints of injuries by this species were received in 1899 until October 18, when Dr. James Fletcher wrote that it was reported to be doing a good deal of harm to violets grown under glass by one of the principal growers of Toronto, Canada. The prominence which was given to this plant-louse in short notes and letters published in various florists' periodicals during the year 1898 led to its general identification in many greenhouses, and our correspondent was aware of the fact that the species was of serious importance in many of the large greenhouses of the United States, including those of Rochester, N. Y.

February 10, 1900, Miss Frances Roberts, Providence, R. I., sent specimens, reporting the species injurious to violets in that city. The beds of the greenhouse were stated to be in ideal condition and the

violets were planted September 15, and, though given the best of careful attention as to air, light, and water, our correspondent succeeded in obtaining nothing but "green" violets.

LITERATURE.

In addition to the technical paper by Mr. Pergande previously noted, several notes and extracts from correspondence have made their appearance in different florists' journals during the past two years in which the species has been studied from the practical side. It has also received consideration in Mr. Galloway's "Commercial Violet Culture," where it is discussed with the so-called green aphid, on pages 198-208. The chapter referred to is devoted principally to the use of the hydrocyanic-acid gas method of treatment for these aphides and has less to do with their biology, although the nature of injury is described somewhat in detail.

In the Transactions of the Royal Society of Canada (Vol. V, second series, 1899-1900, p. 228), Dr. James Fletcher states that this pest had caused much damage to violets during "the past winter," and that it had made its first appearance in Canada about 1897; and, in his "Report of the Entomologist and Botanist for 1899" (1900, pp. 177-178), he has given an account of injury in a large florist's establishment in Toronto. The loss was estimated at \$1,000. Reference to the same matter is given in the Report of the Entomological Society of Ontario for 1899 (1900, p. 110).

Prof. W. G. Johnson briefly noted injury to violets in Maryland during the season of 1900 (Bul. 26, new series, p. 81); also in the American Agriculturist for December 29, 1900, and elsewhere he has furnished some notes on the treatment of a greenhouse in Maryland affected by this plant-louse. One of the owners in this case stated that a single demonstration of this method was worth to him at least \$250 that season.

REMEDIES.

Hydrocyanic-acid gas alone is a sufficient remedy for this species. A spray of neutral soap or of water will also kill the insect. These remedies are treated in previous pages. Concerning the gas treatment, it should be said that it is due to the ravages of this plant-louse in the vicinity of the District of Columbia more than to anything else, perhaps, that the hydrocyanic-acid gas method of treatment was brought to its present state of perfection as a method of controlling insects infesting plants grown under glass. Until the adoption of this means of fumigation, tobacco, which has been in use as a greenhouse insecticide, or, more properly speaking, repellent, for upward of a century, was the remedy most relied upon. The danger of using tobacco in violet greenhouses is treated somewhat at length in an arti-

cle entitled "Combating Aphis on Violets," published by Mr. Gallo way in American Gardening for November 6, 1897 (Vol. XVIII, p. 758), from which the following is quoted:

Aphides, especially the black ones, were once the most serious pests with which we had to contend. Since we have adopted the hydrocyanic-acid gas treatment, however, * * * we have had no serious trouble. So important do we consider this matter of being able to use this gas that we shall plant in the future throughout the entire season in such a way that the plants may be fumigated at any time.

We abandoned tobacco entirely some time ago, as we found by experience that, no matter how used, it would tend to weaken the foliage and make it more subject not only to "spot," but to other diseases as well. * * * When tobacco is used, either as smoke, dust, stems, or extract, it seems to in a measure check the vital functions of the leaf, the little cells of which temporarily lose their vitality and their ability to resist outside influences. Here is the opportunity the fungus needs, and it at once takes advantage of it by sending a thin, thread-like growth into the cells. Once the tissue is entered, the fungus continues to grow until the plant is able to check it of its own accord. The spot then turns white, but when conditions are again favorable the fungus will start anew, and the spot will be found soft, greenish, and watery, etc.

THE VIOLET "GALL FLY."

(*Diplosis violicola* Coq.)

Violets and roses are subject to the attack of different forms of minute larvæ or maggots, the young of what are known to florists as gall flies—minute two-winged flies or gnats of the family Cecidomyiidae. Three species are of importance as enemies of these plants, and there are doubtless others, but these three are the only ones that have obtained marked recognition by their injuries in recent years; until recently, indeed, they were not recognized as distinct from others of their kind. They have been given more or less study by the writer and by some others, and, when it was made manifest that they were undescribed through special study by Mr. D. W. Coquillett, of this office, all of the notes and manuscripts which had accumulated at that time were turned over to him, and the results were embodied in two somewhat technical articles, with full descriptions, in Bulletin No. 22 of the present series.

DESCRIPTION.

The larva or maggot, which is usually found folded up in the leaf of a violet in such a manner as to bring the upper surfaces together in what has been termed a gall, is a minute, legless creature of a whitish or yellowish color. The general appearance of one of these larvæ is shown in figure 16 at *d*, *e* representing its breastbone.

The parent gall fly is a minute, slender and delicate two-winged fly, measuring about one-twentieth of an inch in length. It has long and slender legs and antennæ, the latter 14-jointed and surrounded by two whorls of bristly hairs on joints 3 to 13, inclusive.

The general appearance of the female is shown in figure 16 at *a*, much enlarged, the segments of the antennae being shown still more enlarged at *b*. The genitalia or sexual organs of the male are illustrated, also greatly enlarged, at *c*.

DISTRIBUTION.

It seems probable that this species, like others found in greenhouses, and in habitations, storehouses, and indoors generally, has been introduced from abroad; and it is perhaps tropical, at least in origin. The present known distribution includes the following localities: Washington, D. C.; Richmond and Gordonsville, Va.; Nyack, Tappan, and Cornwall-on-the-Hudson, N. Y.

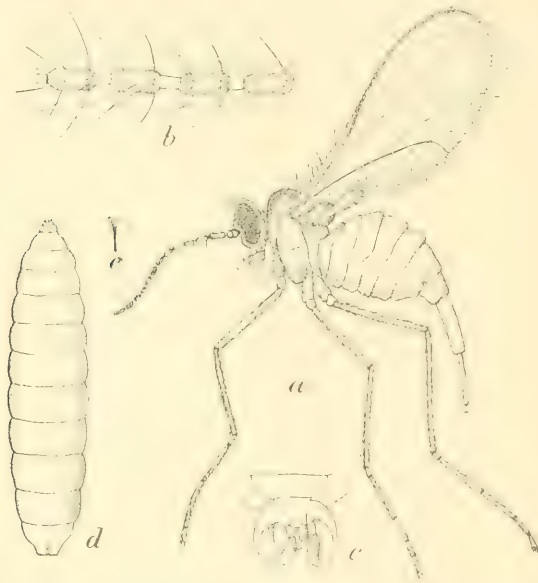


FIG. 16.—*Diplosis violicola*: *a*, female fly; *b*, female antennal joints; *c*, male genitalia; *d*, larva; *e*, breastbone of larva—*a*, *b*, much enlarged; *c*, *d*, *e*, more enlarged (from Coquillett).

This species first attracted attention in 1896, when it was noticed by Mr. Dorsett on sweet violets in the vicinity of Washington, D. C. One of our correspondents, Mr. W. V. V. Powers, writing under date of January 27, 1899, stated that he had noticed this insect three years earlier, and although he could not feel certain that there was any connection between the appearance of this pest and the introduction of the so-styled California violet, it was noticed that they both appeared the same year in his vicinity, Cornwall-on-the-Hudson, N. Y.

NATURE OF INJURY.

The maggots, as previously stated, conceal themselves in folds of the young, growing leaves, causing a distortion or curling into irregu-



LEAVES OF VIOLETS, SHOWING INJURY BY "GALL-FLY" LARVÆ—NATURAL SIZE.
(From photograph by P. H. Dorsett.)

lar shapes, such as are shown in the illustration (Plate III), having somewhat the semblance of a gall, which name has been rather generally applied to them by florists. After the formation of the "gall," what is known as wet rot is apt to set in and destroy the leaves. This has the ultimate effect of dwarfing the plants and of arresting the development of the flower buds.

From the frequency with which maggots resembling those found on the leaves of violets are found in the soil in violet houses, it has been thought that the insects live both in the soil and upon the leaves. It has been thought, also, that this pest is more apt to make its appearance in greenhouses where proper attention has not been paid to the mixing of the soil and to drainage, and that manures of some kinds favor its development. It seems probable, however, in the light of more technical knowledge of the subject that the larvæ found in soil are in nearly every case those of *Mycetophilidæ*, and probably of different species of *Sciara*, several forms of which occur in greenhouses, of which some are reported to be injurious while some are scavengers. One of these species known as the fickle midge will be treated farther on in the present publication.

LITERATURE OF THE SPECIES.

What appears to be the first account that can be with positiveness attributed to this species of "gall fly" was published in the *Florists' Exchange* (Dec. 19, 1896, p. 1132), by Mr. Dorsett. At that time it was not known that this species was different from the so-called gall flies of roses. The account in question is a short one, and is illustrated by a half-tone reproduction of a photograph showing injury to violet leaves by the larvæ. In the same publication (issue of December 3, 1898), Mr. W. Davison wrote of the occurrence of this species at Nyack, N. Y., and in *The American Florist* for January 21, 1899, Dr. L. O. Howard gave a brief summary of what was then known concerning the insect. In Mr. Galloway's "*Commercial Violet Culture*," published the same year, this species is considered on pages 211-214, injuries by the larvæ to the flowers of violet being illustrated.

The aim of the present article is to present in concise, summarized form most of the facts which have already been made public in the articles above quoted.

REMEDIES.

Hydrocyanic acid gas does not appear to have been tested against the violet gall fly, or if it has been used we have no published account of the fact. There is no reason to believe that it would be less effective than when employed against aphides and other insects. Its use is, therefore, suggested. It does not seem practical to pick the leaves, because in such cases the crowns are permanently injured and flowering is checked. Mr. Galloway suggests the use of air-slaked lime,

thrown into the crowns and allowed to reach the soil. If with this the best cultural conditions possible are maintained, such as good ventilation and a frequent stirring of the soil, injury might be greatly lessened. The free use of Buhach, or Persian insect powder, at the time when the mature gall flies are seen flying about the greenhouses and upon the windows, would also be of considerable value in lessening their numbers.

THE VARIEGATED CUTWORM.

(*Peridroma saucia* Huebn.)

Of all violet pests, other than those which have already received special mention in this publication, cutworms of several species as well as allied caterpillars of moths belonging to the same family, the Noctuidæ, and some related families, are most conspicuous. It is seldom that greenhouses are entirely free from them, and the constant vigilance of the florist must frequently be exercised to keep them under control. The leaves of violets are particularly subject to cutworm attack in the spring, after the new plants have been set out.

The cutworms in houses may be produced from eggs laid by moths which have flown in at open doors or windows, but more frequently they are carried indoors with the soil in the fall, and they are most apt to occur in beds in which grass has been permitted to grow, as well as in houses immediately surrounded by dense growths of rank grass and weeds. The reason for this is that a very considerable percentage of the cutworms which attack violets feed normally upon grasses or weeds and it is upon these plants that the moths usually lay their eggs.

Cutworms, as is well known, are most voracious feeders, and in a short time are capable of doing much damage to such small plants as violets. Frequently they cut down whole plants of these and similar ornamental flowers.

What makes these insects difficult to deal with is their nocturnal habit, their presence being seldom detected in the daytime, save by their work, unless during cloudy weather or in secluded dark places.

A common insect met with in recent years on violet and a number of other plants grown under glass is the variegated cutworm (*Peridroma saucia*). It is usually abundant nearly everywhere, and to be found in fields and gardens, pasture land, vineyards, and orchards, as well as in greenhouses. It is one of the best known of our numerous cutworms, one of the most destructive, and appears to be the particular species most often found on ornamental and other plants growing under glass in conservatories as well as in cold-frames. During the season of 1900 it was very destructive over a wide extent of territory, but most conspicuous by its injuries in the Pacific States. Owing to

its destructiveness that season, it received considerable attention at this office as well as elsewhere, and will be given more extended notice in a future bulletin.

DESCRIPTIVE.

The moth which produces this cutworm is a rather large species of the family Noctuidæ. The fore-wings are pale, grayish brown, tinged with reddish and shaded about the middle and toward the outer margin with darker brown, the pattern being variable, but more or less like the form illustrated in figure 17, *a*. The ground color of the hind-wings is iridescent or pearly white, strongly shaded about the margins with shining, light brown, the veins being of the same color and

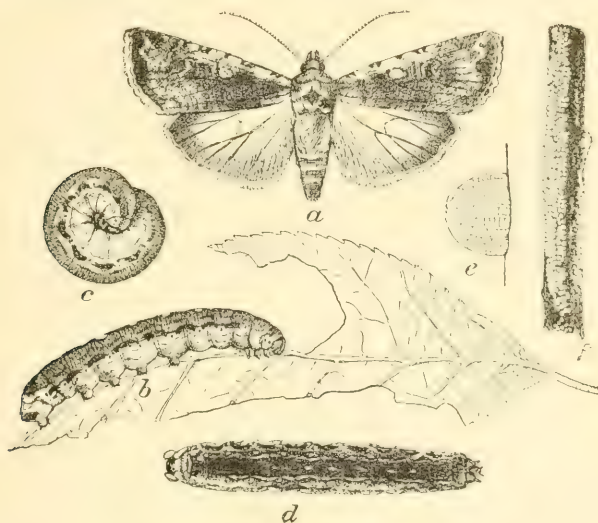


FIG. 17.—*Peridroma saucia*: *a*, moth; *b*, normal form of larva, lateral view; *c*, same in curved position; *d*, dark form, dorsal view; *e*, egg from side; *f*, egg mass on twig (after Howard).

strongly marked. The wing-expanse is about an inch and three-quarters, and the length of the body three-fourths of an inch.

The eggs are deposited in regular masses and often in rows of seven or eight or to the number of sixty or more, preferably it appears, along the twigs of certain fruit trees since egg-masses are often found in such locations. An egg is shown in profile, very much enlarged, at figure 17, *e*, and an egg-mass deposited on a twig at *f*.

The larva.—The larva is very variable, but can usually be distinguished by a row of from four to six yellow rounded spots which occur along the back at the middle of the anterior portion of the body, extending usually from the second to the fifth or seventh segment, as shown in the illustration at *b* and *d*; *d* shows a dark form, while a

lighter form, coiled in the position which the larva assumes when disturbed, is illustrated at *c*. Still lighter larvæ occur.

The pupa presents no obvious characters for description. The color is dark brown at maturity, and the tip of the body ends in a pair of minute spines.

DISTRIBUTION.

Peridroma saucia is cosmopolitan and very widely distributed over Europe, Asia, North Africa, and North and South America. In the United States it is injurious practically throughout the arable region.

During the season of 1900 injury was particularly severe in Washington and Oregon, and was reported also in Texas, Missouri, Kansas, West Virginia, Illinois, and California.

RECENT INJURY IN GREENHOUSES.

Injury in greenhouses has been reported during the past six years to roses and carnation plants near New York City, to carnations at New London, Conn., to cultivated violets at Campbell, Va., and to violets also at Charlottesville, Va. At the last place it was noticed that larvæ ate blossoms as well as leaves.

A list of ornamental plants which have been noted to be affected by this cutworm includes violets, pansies, carnations, roses, smilax, sweet pea, hollyhock, sunflower, and chrysanthemums.

Mr. M. V. Slingerland, in writing of this species and its injuries, in 1895 (Bul. 104, Cornell Univ. Agric. Exp. Sta., p. 581), says:

It would climb up the flower stalks in the evening, and, upon reaching the blossom, would firmly grasp the stalk just below with its prolegs, and then reach out as far as possible onto the petals and eat them down to the base; the outer portion of the petals which it could not reach usually dropped to the ground, often to be eaten by cutworms just coming from their day retreats. One cutworm would thus quickly damage these beautiful blossoms, and frequently two or three of them would completely destroy a whole blossom in a single night.

ON THE LIFE HISTORY OF THE SPECIES.

Considerable has been ascertained in regard to the life history of this species. In fact, we know much more about it than of most cutworms, but published accounts are somewhat conflicting, showing great variability in the life economy of the species not entirely traceable to different environment.

During recent investigations larvæ have frequently been taken during the winter when they have come out to feed on warm days. This, however, is no indication that the species does not also hibernate as a moth and also as pupa, as surmised by Slingerland and others. Egg masses that were found late in the year hatched during the latter days of October. Enough has been learned also to show that an indefinite number of generations can be produced indoors. At this

office we have kept larvæ feeding during October and November and have secured eggs in numbers during the first two weeks of January.

Dr. Riley was doubtless right when he remarked (Rep. Comm. Agric. 1884, p. 298) that his St. Louis notes on the biology of this species "indicate at least two annual generations, with a possibility of three." The climate in the District of Columbia and vicinity is much the same, and the writer feels positive that at least two generations and a smaller third generation are normally produced.

Attack begins as with most cutworms, with larvæ which survive the winter in April and May, and may continue practically without cessation until the latter days of August. The third generation is too small and makes its appearance too late to cause much trouble.

REMEDIES.

After what has been said in the introductory chapter concerning the factors which conduce to the injury of violets by cutworms, it is obvious that one of the first requisites in our efforts at controlling these pests is to avoid for use in the greenhouse soil that has grown up in grasses or weeds that may contain cutworms. To avoid this all that is necessary is to select the soil in the spring and pile it up for use in the fall. In the interim, if no vegetation grows upon the piles, the cutworms will all leave them and thus the soil will be free. This holds true to a certain extent also of some species of white grubs and wireworms, as well as some other insects. If the use of fresh soil is necessary, it should be sterilized by subjecting it to heat. It is advisable also to keep the beds as free as possible from grasses, and not to permit a rank growth of grasses or weeds to accumulate in the immediate vicinity of greenhouses and to keep the houses as tightly closed as possible, especially at dusk and at night, at the time when these moths fly about looking for suitable places for oviposition.

Careful growers keep this insect in subjection in ordinary cases by closely watching for the first evidence of attack and then searching for the insects and destroying them. During the daytime it is not difficult to find them just beneath the surface of the earth about the stems of the plants which they have attacked during the night. By digging in the soil the insects can be discovered without much trouble, and can then be destroyed.

Where fumigation is practiced many cutworms are destroyed, but for plants grown out of doors and in frames if the insects become numerous it may be found necessary to use other than mechanical methods. For this purpose poisoned baits, the standard remedies for cutworms, are the best. Green bait is prepared by spraying a patch of clover or some succulent weed with paris green, one pound to about 150 gallons of water, mowing it close to the ground, and spreading it while fresh about the plants to be protected.

Another bait, known as the bran-arsenic mash, is also valuable for the same purpose, and is prepared by combining one part by weight of white arsenic, one of sugar or a like quantity of molasses, with six of bran, and enough water to form a mash. This is distributed in the same manner as the green bait. Before setting out plants in fields which experience has demonstrated are apt to be infested with cutworms, or in new ground which has been in grass and is therefore liable to contain these insects, it is advisable to use one or the other of these baits.

THE SPOTTED CUTWORM.

(*Noctua c-nigrum* Linn.)

The spotted cutworm, which is also known as the corn cutworm, is one of the best known species of this group occurring in our country.

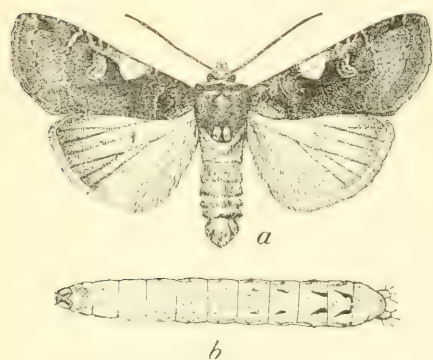


FIG. 18.—*Noctua c-nigrum*: a, moth; b, larva—somewhat enlarged (original).

Like the preceding it appears to be an introduced form, and is common to America, Europe, and Asia. It was found depredating on violets in the late fall of 1899 and 1900 in different portions of Virginia; and other complaints of injuries during the latter year have been received from Indiana, where it was injuring early cabbage and tomatoes; from Connecticut, where it had assumed the army-worm habit, and was eating a great variety of herbage, in-

cluding many cultivated plants, and in Ohio, where it was reported by Professor Webster as injurious in wheat fields in March. It was one of the common species in Maryland during the past year, and in all seasons ranks with the foremost noxious cutworms over considerable territory.

DESCRIPTIVE.

The moth.—The adult of this species of cutworm is a rather attractive and well-marked species. It has brown fore-wings, tinged with reddish in light individuals and purplish in darker ones. The anterior portion of the fore-wings is marked as shown in the illustration. (Fig. 18, a.) The reniform spot is partially suffused laterally, and at a distance of about one-third between it and the thorax is a larger triangular gray spot; back of this, and approaching the reniform, are two black, velvety spots, and there is another one on the anterior margin, near the tip. The collar is pronounced and of a gray color; the

thorax is brown and the abdomen dull gray, a little darker than the hind-wings, which are sometimes strongly infuscated on the outer margins and moderately distinctly veined. The illustration represents a male.

The egg.—The eggs may be laid singly in rows, or in compact layers, sometimes to the number of 200 or more, and when first deposited are nearly transparent, showing the green of the leaf beneath. They are nearly hemispherical in form, and strongly ribbed like many of the Noctuidæ. In consistency they are firm and elastic; each egg is about 9^{mm} in diameter, or a little more than a third of an inch.

The larva.—The young larva, when first hatched, has been described as about 0.04 of an inch (1^{mm}) in length, nearly white in color, and thickly covered with black pilosities. From these pilosities proceed black hairs, which also ornament the head and thoracic shield. The remaining molts have been described as follows by Prof. A. J. Cook (Report Michigan Experiment Station, 1890, p. 108):

After the first molt they were four millimeters (one tenth of an inch) long. A few were still white with eight pilosities to each ring and otherwise as before, while most were now plainly striped with green and white. There is a dorsal white line and two others near together on each side just above the spiracles. The pilosities are less distinct, the hairs white, and the head or under side is white or greenish-white. After the second molt they are one centimeter, or four-tenths of an inch, long. They are now lined with white, and dirty white, or light gray. A wide white stripe on each side contains the brown spiracles in its upper margin, a narrower white stripe extends along the back, while one still narrower divides the distance between the dorsal and lateral stripe about equally. The head and under surface are dirty white. In some specimens the gray is quite darkened by minute black spots, and the lateral stripes are pinkish. The hairs and tubercles bearing them are still more obscure, and as in the previous stages extend all around the body. After the next, or fourth molt, the length is nearly or quite two centimeters. The general appearance is as in the last stage except that the white lines are less clearly defined, while the gray lines are more thickly set with dark olivaceous specks which really make a dark line just above the spiracles.

The mature larva is illustrated at figure 18, *b*. In this stage it measures, when fully extended, about one and one-half inches, and five-sixteenths of a millimeter in width. It is usually an inconspicuous gray or brown in color, sometimes whitish, with strong green or olive-brown tints, and the last three or four, and sometimes all, of the abdominal segments are marked with diverging, velvet-black lines, as shown in the figure.

The pupa is of the usual mahogany brown color of most Noctuid pupæ and measures about three-fourths of an inch in length and one-fourth in diameter. The anal segment terminates in two outwardly curved spines on each side of which there are two shorter curved spines or bristles, and on the ventral surface, just above the insertion of the larger spines, are two similar, still shorter, curved processes.

DISTRIBUTION.

This species is common to North America, northeastern Europe, and northern Asia, and is probably not indigenous to our country, but was introduced many years ago, as has been known to collectors for a considerable period, and was perhaps brought from the mother country in soil about nursery stock or potted plants.

The list of localities which we are at present able to furnish is scarcely indicative of the insect's range. The following are definitely known: Schenectady, N. Y.; New Jersey, common throughout the State (Smith); Storrs, Conn.; Washington, D. C.; Marshall Hall, Cabin John, and Bennings, Md.; Richmond and Poindexter, Va.; Dayton, Ohio (Pilate); Kentland and Chesterton, Ind.; Urbana, Sheldon, and elsewhere in Illinois; Stratmann, Mo.; Volga, S. Dak. (Truman); Montana; Washington, and Oregon.

There are specimens in the National Museum, identified as this species, from Kadiak and Popof islands, Alaska, and we have larvæ, identified as this same species from Savannah, Ga. There is nothing to indicate, however, that the species is established in Alaska; in short, nothing is more likely than that the insect was transported from farther south on the coast—for example, from Washington or Oregon; and the Georgia locality is also doubtful.

With so short a list of definite localities, it is practically impossible to define the insect's geographical limits. The list alone would indicate an exclusively Upper Austral distribution, but the probabilities are that this cutworm inhabits also Transition and perhaps Lower Austral territory. A perusal of all available lists of moths might add somewhat to our knowledge. The species affords a striking example of how little we know of the distribution of some of our most common and destructive species, since this insect is to be classified with the most pernicious of its kind.

RECENT INJURY.

Recent experience with this species of cutworm begins with November 15, 1899, when Hon. G. W. Koiner, Richmond, Va., sent specimens among others, that were depredating on violet beds in Louisa County of that State. The moths issued February 1, 1900.

April 2, 1900, and later this cutworm was taken, together with others, feeding on chickweed (*Stellaria media*) in a garden near Cabin John, Md. At Marshall Hall, Md., where it was found a few days later, it was the most abundant species of cutworm. From this material the moths began issuing May 10. The period of the pupal stage was found to be about four weeks—April 20 to May 18.

May 15 Mr. F. G. Dickinson, Chesterton, Ind., sent larvæ of this species, with the statement that it was one of the cutworms found there attacking early cabbage and tomatoes. He said that it was impossible

to get early plants of these crops started there owing to the ravages of cutworms. The garden had not been in grass for fifteen years, but still about half of the plants were destroyed by these insects.

In early August the spotted cutworm assumed the army-worm habit in at least one locality. August 6, Prof. B. F. Koons, of the Connecticut Agricultural College at Storrs, Conn., sent a number of living cutworms of this species with the accompanying information that they first attracted his attention in a large meadow, where they were tumbling into the water of a ditch, being particularly abundant along its border, where they fed upon weeds, ferns, golden-rod, and other plants, not cutting them, however, but eating the lower foliage. They were traveling like the army worm in considerable numbers, and not feeding upon oats or grasses, but upon netted-veined leaves. They riddled a small plot of rhubarb on the hillside near the meadow, filling the leaves full of holes, and attacked also the fruit of tomato near by. They were found also in great numbers coiled about the roots of weeds and in rubbish at their bases, and they were as abundant along the borders of the ditch as our correspondent had ever seen the true army worm, *Leucania unipuncta*. The moths of this lot, which may be considered the second generation of larvæ, began issuing about the middle of August. The pupal stage during hot weather was fifteen days.

This is the third instance known to the writer of this species assuming the habit of traveling in armies. On page 135 of the Third Report of the United States Entomological Commission, Dr. Howard states that in his investigations of the true army worm (in Illinois and Indiana) in 1881 this species was accompanied by large numbers of the spotted cutworm in the proportion of about one of the cutworms to five of the army worms. During the same year Mr. Coquillett observed this cutworm in Illinois associated with the army worm in the proportion of one of the former to eight or ten of the latter (Eleventh Report State Entomologist of Illinois, 1882, p. 51).

December 6, 1900, Mr. G. W. Morris, Poindexter, Va., sent specimens of this cutworm with report that they were devouring violets upon his place, eating both blooms and leaves of the plants.

Brief mention of the occurrence of this larva on violets in September and October in Illinois has been made by Messrs. Forbes and Hart (Bul. 60, Univ. of Ill. Agric. Exp. Sta., 1900, p. 451).

A note on the extreme abundance of this species in many localities along the north shore of Lake Ontario, where it was injurious to all kinds of garden and root crops, was given by Dr. James Fletcher in an article published in the Thirty-first Annual Report of the Entomological Society of Ontario for 1900 (1901 p. 68). The generation of larvæ found during July was in the year 1900—the one that did most harm. It seemed to take the place in Ontario of the variegated cutworm, which was injurious in the West.

LIFE HISTORY AND HABITS.

The European food plants which have been recorded for this species include *Rumex* (dock or sorrel), *Stellaria media* (chickweed), *Primula* (primrose), *Thalictrum* (meadow rue), *Epilobium palustre*, *Myosotis*, *Verbascum*, and *Lamium*.

Chickweed, in the writer's experience, is the favorite food of this as well as some other cutworms. Violets are quite subject to attack, as are also cabbage and tomato, ferns, goldenrod, rhubarb, *Lobelia*, *Helianthus*, chicory (*Cichorium intybus*), currant, celery, corn, grasses, and clover. The fruit of tomato is sometimes injured. Young larvæ devour their own eggshells, and a larva has been seen to feed upon the egg pods of locusts.

The species frequently assumes the climbing, and, less often, what is known as the army-worm habit.

It seems probable, from what the writer has been able to learn from experience and inquiry, that the larvæ are rather partial to the foliage of some fruit trees, since they are so frequently found in orchards, but the climbing habit has been noticed only in a few localities.

The life history of this species has never been fully traced, but, from the observations of Messrs. Coquillett, French, and Forbes in Illinois, it is evidently two-brooded, at least in the northern portion of that state. The imagoes of the first generation appear in May and early June, and those of the second late in July and in August. It is proved beyond peradventure that hibernation takes place in the larval condition; probably only in this stage and not as pupa or moth. As an example of development in midsummer, Professor Forbes states (Sixteenth Report State Entom. Ill., 1890, p. 86) that ten larvæ, taken from cabbage July 16, entered the earth for pupation July 25 and emerged as adults August 15 to 19, these individuals having remained in the earth from twenty-one to twenty-five days. Forbes has observed that this species rarely appears at electric lights, an observation that is borne out by the writer's experience also.

Injury by this cutworm appears to be done chiefly by the hibernated or spring generation, the larvæ doing little if any appreciable damage in the autumn. In Illinois larvæ are said not to be particularly troublesome after the first part of May. Larvæ have been observed in the fields in and near the District of Columbia late in November and have been kept feeding in rearing cages out of doors exposed to the weather as late as January, in which respect this cutworm resembles *Peridroma saucia*, also a European importation.

NATURAL ENEMIES.

This cutworm being one of several species which sometimes rest during the day under stones, it is at such times sought out by parasitic insects for the deposition of their eggs.

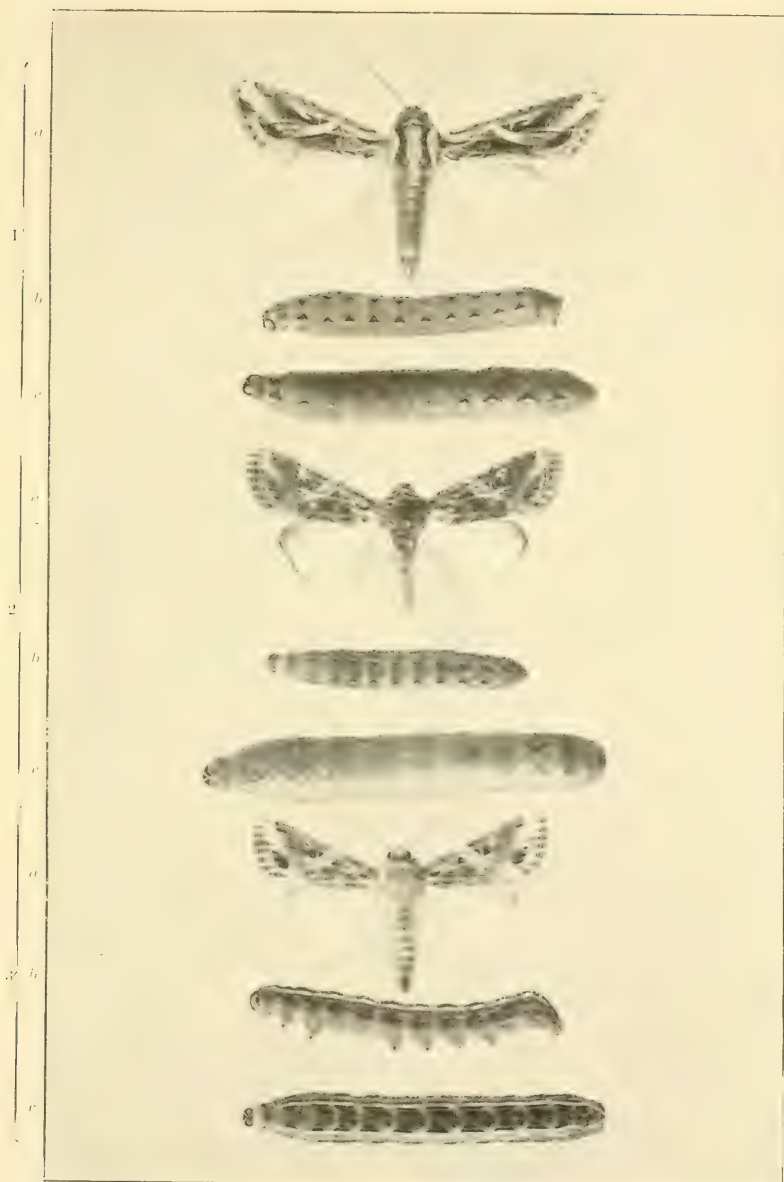


Fig. 1.—*Prodenia commelinae*: a, moth; b, penultimate stage of larva from above; c, mature larva from side.

Fig. 2.—*P. ornithogalli*: a, moth; b, penultimate stage of larva from above; c, mature larva from side.

Fig. 3.—*P. endiopa*: a, moth; b, larva from side; c, larva from above—all slightly enlarged (original).

Ichneumon comes Cr. was reared from the pupa of this cutworm June 5, the host having transformed to pupa May 7, 1900. Locality, Marshall Hall, Md.

Apanteles sp. (near *glomeratus*) has been bred from a larva of this moth in about 60 individuals. April 7 the host larva was found dead and the parasites spun up in a white flocculent mass of cocoons, measuring a little less than an inch in diameter and half an inch in thickness. From this mass the adult parasites issued April 23.

REMEDIES.

The spotted cutworm is amenable to the same remedies prescribed for use against the variegated cutworm treated in preceding pages.

THE COMMELINA OWLET MOTH.

(*Prodenia commelina* S. & A.)

A conspicuously marked caterpillar that preys upon violets is produced by a moth which Smith and Abbot described over a century ago under the name of *Phalaena commelinae*. Comparatively little is known of its food habits, but what has been learned shows that it is inclined to be omnivorous, as it has been found to be destructive to the foliage of sweet potato and cotton, and to attack asparagus and raspberry among cultivated plants. It is one of three species of *Prodenia* which inhabit the Central Atlantic States, but are more numerous in the Gulf States.

In their more northern range these larvæ appear to be more diurnal than most cutworms, and are frequently to be found in shady places in the afternoon feeding in free exposure upon their food plants. Their normal habit is evidently crepuscular and they are rather peculiarly solitary, and perhaps for these reasons they attract little attention on account of injuries. The genus, however, is well known on account of the striking colors of the larvæ as well as of the mature insects or moths.

DESCRIPTIVE.

The moth.—The adult of this species may readily be distinguished from its two more common congeners, which are here considered, by its greater wing-expanse, darker colors, and less complicated markings. The color of the fore-wings is, in fresh specimens, moderately dark rich brown, velvety in the darkest portions, where it is variegated with black in transverse lines, paler purplish brown, and dull yellow and ochreous. The pattern formed is illustrated at figure 20, *a* and figure 1 of Plate IV. The thorax is similarly colored, as is also the head, and the abdomen is paler, more uniform, grayish brown. It is rather wide and tapers strongly toward the tip. The hind-wings are pale pearl-gray with a strong violet iridescence, which is visible also on the lower

surface. The wing-expanse is about $1\frac{3}{4}$ to 2 inches (45–50^{mm}) and the length of the body is about nine-tenths of an inch (23^{mm}).

The eggs of this species, or for that matter of the genus *Prodenia*, do not appear to have been described. From preserved specimens, however, of an empty egg mass it is obvious that they are nearly duplicates of *Laphygma* in appearance, the mass itself being covered with gray hairs as in the latter genus.

The larva.—The general color of the larva is a peculiar olive or greenish brown, more or less variable, finely lined with dark gray and brown, and this as well as other species of the genus which will be discussed are all ornamented on the upper surface with a double row of triangular, velvety-black, sometimes greenish, spots, which give them a striking appearance. The larvæ are in fact so peculiarly marked that it is not at all difficult to separate this genus from any other common genus of the same family occurring in the Eastern

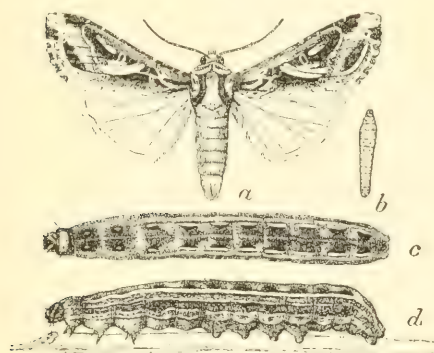


FIG. 19.—*Prodenia commelina*: a, moth; b, young larva; c, mature larva, dorsal view; d, same, lateral view—all slightly enlarged (original).

States. The larva of this species may be distinguished in all stages, except the final stage, by the greater number of these dorsal black spots and the lack of striation so visible in the other two. The body is cylindrical and smooth; the head is small and polished black or dark brown in front, shading off into lighter brown at the posterior end and at the sides, with the frontal triangle margined with white. The thoracic plate is dull brown or blackish with the piliferous spots and median line dull yellowish, and the second thoracic segment has two usually large, deep-black dorsal spots. The dorsum is also marked with a median row of small yellow dots. The stigmata are black with pale centers, the thoracic legs brown, the abdominal legs dark green externally, and the hooklets dark brown; inflated larvæ are rather dark reddish-brown.

The length is between one and one-half and one and three-fourths inches (38–45^{mm}), the diameter 10–12^{mm}.

Technical descriptions of the various stages of the larvæ have been kindly drawn up by Dr. H. G. Dyar, and are appended.

The mature larva of a well-marked form is shown at figure 19, c and d, a young larva being illustrated by b.

LARVAL STAGES OF *PRODENIA COMMELINE*.

Stage I.—Head rounded, bilobed, shining brown-black; clypeus moderate; mouth slightly projecting; antennæ small, normal; width, 0.3^{mm}. Body slightly enlarged

at joints 3-4, and 12, cylindrical, normal, the feet small, equal, thoracic ones black. Whitish; a red-brown lateral patch on joints 5 and 11, with faint traces about tubercle iv on joints 6 to 8 of red-brown. Cervical shield distinct, transverse, slightly excavate behind, with the leg shields and tubercles brown-black. Tubercles distinct, rounded, moderate, normal. Anal shield small, brown-black.

Stage II.—Head rounded, bilobed, about as high as wide, greenish testaceous; width, 0.5^{mm}. Body shaped as before, but the shields and plates scarcely cornified, obscure, concolorous; tubercles minute, setae small. Green. the dark brown patches on joints 5 and 11 large, covering the spiracle and a small rounded subdorsal one on joint 3. Numerous longitudinal white lines consisting of dorsal, subdorsal (upper and lower), lateral, substigmatal (upper and lower); feet all pale.

Stage III.—Head rounded, wider than high, slightly bilobed, the lobes full in front, the clypeus reaching two-thirds to the vertex; greenish testaceous, a brown patch before on each lobe; width, 0.8^{mm}. Body shaped and colored as before, the region between the lower subdorsal and substigmatal lines reddish and containing traces of a supra-stigmatal white line; subventer slightly reddish.

Stage IV.—Head as before, shining brownish testaceous, clypeus rather high, two-thirds, ocelli large, black; width, 1.3^{mm}. Body cylindrical, enlarged at joints 3-5 and tapering to the head, enlarged also dorsally at joint 12. Feet moderate, equal. Shields and tubercles obsolescent, setae minute except at the extremities. Green; dorsal line narrow, white, obscure; lower subdorsal rather broad, distinct, white, shaded with orange, angled on the hump on joint 12; the two substigmatal lines parallel, waved, subconfluent by mottlings, forming a broad, sharply edged band centered with brown and shaded with orange in spots. Other lines broken, dotted, confused with strigae. Dark brown subdorsal patch on joint 3 and lateral ones on joints 5 and 11 as before. Body more or less mottled with brown between the strigae. Concolorous cervical shield cut by three white lines; thoracic feet brown; abdominal ones green, brown shielded.

Stage V.—Head as before, shining brown, reticulate with darker on the sides, the same dark color shading the clypeus, labrum, and edges of the pale paraclypeal pieces; width, 2 to 2.2^{mm}. Body as before, the enlargements less marked. Green, densely mottled reticulate with brown and whitish dots, the lines obsolescent, lost in the mottlings, except the lower subdorsal, which persists as a series of white dashes on the centers of joints 3 to 12, each dash forming the lower edge of a triangular brown-black patch, those of joints 3 and 12 the largest, the central ones smaller and sometimes not developed. A lateral patch on joints 5 and 11. Upper subventral line indicated, narrow, waved, reddish. Dorsal line indicated, distinct on joints 2 and 3. Cervical shield olivaceous brown with three pale lines; anal plate concolorous; feet greenish; slight irregular black dottings on joint 13 dorsally.

Stage VI.—Head broad, rounded, bilobed, clypeus large, reaching over two-thirds to the vertex; brown, marked as before, the reticulations not prominent; not retracted in joint 2; width, 3^{mm}. Body cylindrical, normal, gently enlarged at joints 3 to 5 and 12, tapering only at joints 2 and 13; feet moderate, normal. Densely and finely mottled with brown and whitish, the marks as before but somewhat more defined. Subdorsal velvety black triangular patches, usually subequal on joints 3 to 12, edged below by a yellow-white line, becoming a dot on joint 4, or the central ones smaller or absent, but those on joints 3, 11, and 12 persistent. Other lines obsolete or represented by traces except the dorsal on joints 2 and 3, which is narrow, pale. Cervical shield olivaceous with dorsal line only or traces of the pale subdorsal also; anal plate small, olivaceous. Black dottings of joint 13 absent in faintly marked examples. Spiracles black; feet greenish. Tubercle iv on joint 5 above the middle of the spiracle, on joints 6 to 8 above the lower angle, on 9 and 10 below the middle, on 11 halfway to tubercle v, on 12 at the lower angle of the spiracle.—[H. G. DYAR.]

The pupa is of the customary Noctuid color, mahogany brown, and is of robust form, measuring about five-eighths of an inch (16^{mm}) in length, and a little more than one-fifth of an inch (5^{mm}) in width. No characters are apparent, from a casual glance, to distinguish this genus from allied ones. The anal extremity terminates in two small divaricating processes, a character of many Noctuid pupæ.

DISTRIBUTION.

This species of *Prodenia*, as previously stated, is the rarest of the three common eastern forms, and although we have received material identified as *P. commelinæ* from Ashby, Mass., and it is recorded by Dr. J. B. Smith from that State, our list of definite localities appears to indicate that it is Lower Austral, and not so well established in the Upper Austral region as the other two species under discussion.

At the present writing we can furnish only the following short list of localities: "Massachusetts"; District of Columbia; Charlottesville and Colonial Beach, Va.; St. Louis, Mo.; Illinois; Macon, Ga.; Alabama; Lake City, Fla.; and Texas.

THE QUESTION OF NOMENCLATURE.

A glance at the synonymy furnished for the genus *Prodenia* by Dr. Smith in his catalogue of the Noctuidæ, published as Bulletin No. 44 of the United States National Museum (p. 169), is sufficient to show that considerable confusion exists in published accounts as to the identity of the different species. According to Smith the "wheat cutworm" mentioned and discussed by the late Dr. Riley in his First Missouri Report (pp. 87, 88), and which he again mentions and figures (as moth) in his Third Report (p. 113, fig. 48, *b*), is *ornithogalli* and not *comelinæ*, by which both this figure and *c* of the same illustration are designated.

This subject is discussed on page 43 of volume II of *Papilio*, as also in the Index to the Missouri Reports (p. 56).

DIVISIONAL RECORDS OF OCCURRENCES.

During recent years this species has been reported as injurious only in 1898. November 10 of that year we received from Mrs. H. B. Boone, Charlottesville, Va., specimens of the larva found feeding upon violets grown in beds at that place; but there is an earlier record of injury during the same year. This is by Mr. A. L. Quaintance, and was published in the *Farmer and Fruit Grower* of October 8, 1898, and it is evident from this account that the species is coming to the fore as a garden pest, at least in the South. The account in question relates to damage to the foliage of sweet potato by the larva of this Noctuid "throughout the State" of Florida. Reports had come in from various localities indicating that the species was widespread in its occurrence there. During feeding, the young were noticed to con-

gregate more or less on the under surface of the leaves and to eat through to the epidermis of the upper surface. With increased growth large holes were eaten entirely through the leaves, and a leaf would in some cases be completely devoured except some of the larger veins.

There are among office records two of the earlier occurrences of this species, one at St. Louis, Mo., where this species was stated to be feeding in its larval state upon the leaves of apple and peach, but in confinement only, and another dated May 13, 1884, of the receipt of specimens from Ashby, Mass., where the larva was stated to have done much damage to the buds of grape, and apple and other fruit trees; but as the moths reared are not to be found among our *Prodenias*, it is fair to presume that the person who identified the species may have been at fault. In short, there is nothing to show that this or other species of the genus ever assume the climbing habit, as is the case with the spotted cutworm, *Noctua c-nigrum*, which somewhat resembles *Prodenia* in the pattern of the markings of the dorsal surface. There is also a record of the larva identified as *P. commelinae* eating holes into the leaves of raspberry, May 30, 1879, at Ithaca, N. Y., but it is not stated that this occurred in the field. Larvæ of this species have several times been taken on grass by the writer and others in the District of Columbia.

PUBLISHED RECORDS.

Smith and Abbot's description appeared in the year 1797 in *Natural History of the Rarer Lepidopterous Insects of Georgia* (Vol. II, p. 189, Plate XCV). The specific name was derived from the insect's food plant, *Commelina communis* Linn. We quote the original description and remarks:

Ph. *Noctua spirilinguis cristata*, alis deflexis: primoribus fusco-nebulosis litura diffracta maculaque ad apicem flavescens posticis albidis.

Feeds on Wild Comfrey (*Commelina communis*), Hickory, Groundpeas, etc. It went into the ground August 19, and the fly came out the 10th of September. This moth, though found also in Virginia, is not very common.

The illustration furnished of the moth is quite recognizable, but that of the larva might serve about equally well for *ornithogalli* or *eudiopta*, our other common species.

Smith and Abbot gave this species the name of *Commelina* or wild-comfrey owlet moth, and the first name we may retain for lack of a better one, since another plant, *Cynoglossum virginicum*, is the one recognized by present-day botanists as wild comfrey.

In Glover's "Manuscript Notes from My Journal" (p. 60), two references are made to *Prodenia commelinae* in his own earlier accounts in Patent Office Reports for the years 1854 and 1855, respectively, but these accounts can not be referred to the species in question with any degree of certainty. Mention has been made by the writer in Bulletin No. 10 (new series, p. 60) of the occurrence of this species on asparagus at Colonial Beach, Va., in August.

NATURAL ENEMIES.

The habit of this larva of crawling distances in exposed situations, as, for example, across roads and sidewalks, together with its bright and conspicuous colors and large size, would seem to render it peculiarly subject to the attack of natural enemies, but as yet only one of these has been observed.

There is in the National Museum a specimen of the larva which bears upon the thoracic segments eggs of a *Tachina* fly, deposited in the usual manner transversely upon the dorsum. The adult was not reared, and no *Tachina* fly appears to be recorded as attacking this or other species of the genus.

Several times during rearing experiments larvæ that had just been taken from the field were observed to be dying of a fungous or bacterial disease, evidently the same one that is so prevalent with *Plusia brassicæ*, the cabbage looper, and similar species.

REMEDIES.

It has been reported by Mr. Quaintance (l. c.) that this species was successfully treated at the Florida experiment station with a spray of 1 ounce of Paris green to 10 gallons of water, with the addition of 1 or 2 ounces of quicklime.

Other remedies, such as poisoned baits and the like, are valuable. See account of variegated cutworm.

THE COTTON CUTWORM.

(*Prodenia ornithogalli* Guen.)

The most abundant and destructive, and consequently the best known, of the three species of *Prodenia* under discussion has been called the cotton cutworm, *Prodenia ornithogalli* Gn. Larvæ were found in considerable numbers on violet at Garrett Park, Md., during October, 1898, and were taken at intervals, although in much decreased numbers, during the following year; but in 1900 larvæ reappeared in numbers, in some cases occurring indoors as well as in the fields. The moths also returned in their customary abundance to the electric lights, where in ordinary autumn weather they are among our commonest Noctuids.

This species, like the preceding, is a general feeder, and has been noted to attack cotton bolls and the fruit of tomato in the same manner as does the cotton boll worm. In short, it has what is termed the boll-worm habit.

DESCRIPTIVE.

The moth.—The moth of this species can readily be distinguished from *commelina* by the much more complicated pattern of the fore-

wings, its smaller size, and less iridescent hind-wings. The thorax lacks the two longitudinal stripes seen in *commelinae*. There is a submarginal vein of the hind-wings which shows very distinctly, and all the veins of the hind-wings, particularly the inner ones toward the abdomen, are more distinctly marked than in the preceding species. The average wing expanse is a little less than one and one-half inches (36^{mm}), and the length of the body is about seven-eighths of an inch (22^{mm}). One individual of this species taken recently measures a little less than 1 $\frac{3}{4}$ inches. There is considerable variability in the depth of coloration, fresh specimens being as dark as *commelina*, but soon fading. The general appearance of the moth of this species is shown at figure 2, *a* of Plate IV.

In the year 1875 Dr. Leon. F. Harvey described this species (Bul. Buff. Soc. Nat. Sci., Vol. II, pp. 274, 275) under the name *lineatella*, but Dr. Smith's recent studies show that this name is antedated by Guenée's *ornithogalli*. The latter description appeared in 1852 (Spec. Gen. Noct., Vol. I, p. 163).

P. flavimedia Harv. (which is now recognized as the *c* of the Missouri figure above referred to) in like manner becomes *eadipta* Gn.

It has several times been described in print, but a thoroughly satisfactory comparative description has not appeared.

Technical descriptions of several of the stages of the larva drawn up by Dr. Dyar are appended:

LARVAL STAGES OF PRODENIA ORNITHOGALLI.

Stage I.—Similar to *commelinae*. Whitish, the head, tubercles, and shields black. The newly hatched larva is unspotted, but toward the end of the stage the body becomes faintly green from the food with faint subdorsal, dorsal, and stigmatal white lines, a red lateral patch on joint 5, and a diffuse streak on joints 11 and 12. Head rounded, slightly bilobed, polished black; mouth squarely projecting. Cervical shield small, black, transverse, slightly pointed centrally in front. Tubercles small, black, normal, no subprimaries; ia to iib of thorax all separate, iia minute. Anal plate and leg-shields black.

Stage II.—Head rounded, slightly bilobed, clypeus high; shining translucent light brown with a reddish shade at the vertex; ocelli black. Body gently enlarged at joints 3 to 5 and 12, rather robust, normal. Green, slightly tinged with reddish especially dorsally posteriorly; a rounded, elevate, red-brown spot laterally on joint 5 and a shade on joints 11 and 12. Dorsal line white, upper subdorsal faint, lower distinct; a fainter lateral line and two parallel fine ones below the spiracle. Tubercles black, distinct, normal. Cervical shield brown, cut by whitish lines; anal shield small, dusky. Feet normal with dusky plates.

Stage III.—Head as in the next stage, pale brown, the paraclypeus pale. Body greenish, with lines as in *commelinae*, but more numerous, consisting of dorsal, subdorsal (upper and lower), lateral (upper and lower), suprastigmatal, substigmatal (upper and lower); a black subdorsal spot on joint 3, and a large elevated lateral one on joint 5. Substigmatal line, hump of joint 12 and subventer faintly shaded in vinous. Feet all pale.

Stage IV.—Head rounded, wider than high, slightly bilobed, the lobes full in front, the clypeus reaching two-thirds to the vertex, brownish testaceous, subreticulate,

the paraclypeus pale. Body normal, gently enlarged at joints 3-5, and 12, rather robust; feet small, normal. Shields membranous, tubercles and setæ minute. Green, shaded with vinous brown, especially on dorsal line and subventrally. Dorsal line white, narrow, spotted with vinous shading; upper subdorsal narrow, lower broad, both white, the latter angled on the hump of joint 12; a black spot between them on joint 3. Lateral line narrow, white, with a fainter line above it; a faint suprastigmatal white line; substigmatal lines parallel, narrow, white, waved, joined into a sharp-edged band by vinous shading. Subventer faintly vinous shaded, white dotted. A square lateral black patch on joint 5. Concolorous cervical shield cut by three white lines. Feet plates brown.

Stage V.—Head as before, shining dark brown, paler on the sides, paraclypeal pieces contrastingly pale. Body as before, the enlargements less marked. Shaded with brown and vinous, obscuring the ground color, sparsely white strigose between the lines. Lines distinct generally. Dorsal line narrow, broken, vinous edged, obscure; upper subdorsal likewise narrow and reduced; lower subdorsal broad, distinct, edged above by segmentary brown patches, fainter than but similar to the one on joint 3; upper and lower lateral lines broken, mottled, but not obscured; suprastigmatal line fine and broken; subventral line narrow, waved, centered by red about as before. Cervical shield and anal plate brown, trisected in white. Feet brownish. Lateral patch on joint 5 brown-black, distinct.

Stage VI.—Head broad, rounded, bilobed, clypeus large, reaching over two-thirds to the vertex; brown, dark on the face, cut by the pale contrasting paraclypeal pieces. Body cylindrical, normal, shaped as in *commelineæ*. Densely and finely mottled with whitish dots on a brown ground, the marks as before but better defined. Dorsal line diffuse, red, obscurely pale centered; subdorsal distinct, broad, yellowish white, faint on joint 2, surmounted by a row of triangular brown spots on joints 3-13, cut pulverulently by the broken upper subdorsal and separated by pale intersegmental shades. Lateral area on joints 5-12 marked by upper and lower lateral lines, the lower broader but both subconfluent by mottlings with each other and the lower subdorsal, scarcely developed on joints 2-4 or 13. A faint suprastigmatal mottled and broken line. Substigmatal band, broad, red, white dotted, edged by the narrow lines; subventer white dotted. Shields and plates pale brown, the cervical faintly trisected by white; spiracles black. A brown patch on joint 5 between the lower lateral line and spiracle. Tubercular formula as in *commelineæ*. [H. G. DYAR.]

From the description which has been given of the larva of *commelineæ* in treating of that species, enough has been said to show that the principal difference between these two species consists in the greater striation of *ornithogalli* and in the fact that the dorsal velvety spots are many of them lost in the last two molts. The question of the separation of these three forms of larvæ can best be expressed in tabular form as follows:

Ground color gray, closely streaked with fine, very irregularly undulating lines.

Upper line of latero-dorsal stripe always interrupted, usually yellow, the lower line faint or absent.

Longitudinal stripes not strongly marked *commelineæ*.

Ground color similar.

Upper line of latero-dorsal stripe, usually more or less continuous, often white or very pale yellow, lower line distinct, though narrow.

ornithogalli.

Ground color darker, and all stripes and other markings more pronounced and more beautiful, but the arrangement is little, if at all, different.

eudiopta.

The penultimate stage of the larva of *ornithogalli* is shown at figure 2, *b*, of Plate IV, and the final stage at *c* of the same figure. The length of the mature larva is from one and one-half to one and three-fourths inches and five-sixteenths of an inch is the width (of inflated specimens). It should be added that the figures presented of this larva are not as good as could be desired partly on account of their imperfect inflation.

DISTRIBUTION.

According to specimens in the National Museum, Divisional records of occurrence, and such few published records as have been consulted, it is obvious that this species is widely distributed through the Upper and Lower Austral life zones from Massachusetts and New York southward to Texas and westward to California. In New Jersey it is credited by Smith as occurring "throughout the State," and the New York locality is recorded by Harvey. Its occurrence in the latter state, however, does not appear to be noted in any of the fifteen Annual Reports of Doctors Lintner and Felt that have appeared to date, and as no definite locality in that State or in Massachusetts has been specified it would seem that the species is rare so far north, if, indeed, it occurs there at all in the larval condition. The same holds good for Minnesota, where the moth has been captured. This species is evidently one of several comparatively well known Lower Austral forms of moths which are able during the summer and autumn to extend their range, principally by flight, well into the Upper Austral region, where occasionally, as happened in 1889, numbers succumb during severe winters.

The list of localities which will be given, though short, may serve as a basis for additions which will indicate more clearly the range of this insect: New York; New Jersey; Lancaster, Pa.; Berwyn, Cabin John, Garrett Park, Md.; Tennallytown and Brookland, D. C.; Dayton, Ohio (Pilate); Lafayette, Ind.; St. Anthony Park (Lugger), Texas Parish, Ashwood, La.; Holly Springs, Miss.; Archer, Fla.; Gainesville, Tex.; Lawrence, Clay County, Kans.; Fountain, Okla.; St. Francis County, Ark.; Savannah, Griffin, Ga.; Raleigh, N. C., and California.

RECENT OCCURRENCE.

This species has come under observation quite frequently during the past three years through the occurrence of larvæ upon cultivated and other plants. Prior to this date and during 1898 the moths were quite frequently seen at electric lights, particularly during autumn, but in 1899 there was a considerable diminution in their numbers, as has been related elsewhere, while in 1900 the moths returned to lights in numbers approximating their former and normal abundance.

During 1898 several larvæ were brought to the office at different times in late August and early September by Mr. P. H. Dorsett found feeding upon violets at Garrett Park, Md., and were also taken by the writer upon potted violets on the Department grounds. A larva which was nearly full grown September 6, 1898, and which entered the ground a day or two later, issued as moth October 16. From larvæ obtained from the same source September 29 moths were obtained November 10. A larva received on greenhouse violets October 14 issued as a moth in a warm room January 7, 1899.

During 1899 this larva was met with on only two occasions, early in September, when the species was found feeding upon the hogweed, *Amaranthus retroflexus*, on the Department grounds. A moth from this lot was reared September 27, 1899.

October 7 three larvæ were taken by Mr. Pratt on asparagus in the District of Columbia.

June 11, 1900, Mr. T. C. Knoop, Fountain, Okla., sent larvæ of this species with report that they were injurious to garden plants, and especially to cabbage. They were noticed in great numbers in the evening, and were seldom found during the day. They were stated to have destroyed several thousand plants on our correspondent's farm, necessitating much replanting.

July 1 a larva taken on tomato at Cabin John, Md., was one-fourth grown. At the end of a week it was three-fourths grown. The moth issued July 28. July 9 a larva was observed attacking cucumber at Cabin John, Md.

Larvæ were subsequently taken about Washington, D. C., at intervals in late September and in October, on tomato and on morning glory, moths from which issued as late as the latter days of November.

October 13 Mr. H. Walter McWilliams, Griffin, Ga., sent the larva with report that these "worms" were destroying ruta-baga turnips, field-pea vines, rape, and everything belonging to the cabbage and pea families of plants. The specimen received bore numerous eggs of a *Tachina* fly on the head and thorax.

EARLY DIVISIONAL RECORDS.

Our office notes concerning this species begin with the date August 27, 1881, when we received larvæ taken at Savannah, Ga. March 10, 1882, we received from Mr. Albert Koebele, Archer, Fla., a larva taken in a cotton field.

Eggs obtained from a moth of this species taken in the District of Columbia August 22 hatched on the 25th.

June 30, 1885, a larva was received from Mr. J. H. Ragsdale, Gainesville, Tex., where it was found feeding on cotton.

May 1, 1888, we received a lot of larvæ from Mr. F. M. Webster, at that time at Ashwood, La., found depredating on corn and cabbage.

The lower leaves of corn were first attacked, and then the "worms" fed on the tender unfolded leaves higher up.

June 30 of the same year Mr. Webster again sent the larvæ of this species from Lafayette, Ind., where it was also found feeding on corn.

October 28, 1890, we received the larva from Mr. F. W. Mally, Holly Springs, Miss., where it was found feeding on cotton.

June 6, 1896, we received the larvæ from Prof. F. H. Snow, Lawrence, Kans., with the report that they were destroying late-planted corn in Clay County of that State, eating both leaves and stalk down to the ground.

We have also obtained the larva from Raleigh, N. C., reported on cottonwood.

Some of the above facts have been briefly repeated by Mr. Webster in Bulletin 45 of the Ohio Agricultural Experiment Station (p. 187).

ECONOMIC LITERATURE.

This species has received comparatively little attention in economic literature. In the Tenth Report of the State Entomologist of Illinois (p. 139), Mr. John Marten makes mention of the feeding of the caterpillar on salsify. This note, however, was based upon observations made in confinement, and there is no evidence to show that the insect sought the salsify from choice.

In *Insect Life* (Vol. II, p. 382) Mr. F. M. Webster notes the occurrence of full-grown larvæ at Lafayette, Ind., October 29, 1888. In the same publication (Vol. III, p. 149) Mr. Webster states that the larvæ were observed in considerable numbers in April, 1888, in Texas Parish, La., depredating upon young corn. They were also observed the same month riddling the leaves of cabbage in gardens, as also in St. Francis County, Ark., ravaging fields of potatoes, eating every vestige of a leaf from them. June 26, of the same year, young larvæ were observed at Lafayette, Ind., feeding upon the parenchyma of leaves of wheat, and a few days later upon cabbage. Still later they were feeding upon the foliage of late-planted corn.

In Bulletin 24 (o. s.) of this Division (p. 24) Mr. F. W. Mally notices the occurrence of the larva on cotton and states that it enters nearly grown bolls, feeding on their contents in much the same manner as the boll worm. Mr. Ashmead also noticed this species feeding upon cotton bolls and records the fact that it had been observed attacking young cotton plants as they appeared above ground, acres being sometimes destroyed and having to be reset to secure a good crop. The pupal stage was ascertained to be between twelve and thirteen days in August in Mississippi (*Insect Life*, Vol. VII, pp. 324, 325).

The occurrence of this cutworm upon asparagus at Berwyn, Md., and in the District of Columbia, in August and September, 1896, has been recorded by the writer (Bul. 10, new series, p. 60).

This is one of the common caterpillars in Illinois beet fields, according to Messrs. Forbes and Hart (Bul. 60, Univ. Ill. Agric. Exp. Sta., 1900, pp. 496-497), being found most abundantly in the caterpillar state in July and August.

FOOD AND OTHER HABITS.

A list of larval food plants has been compiled by Messrs. Forbes and Hart which includes besides cotton, beets, corn, wheat, cabbage, potato, asparagus, salsify, peach, and raspberry. To this list may now be added the foliage of violets, asparagus, cucumber, tomato, morning glory, turnips, pea, rape, ruta-baga, pigweed, cottonwood, and grasses. It seems probable that many more plants will be added in course of time. Injury has also been noted to the bolls of cotton and fruit of tomato.

Our knowledge of the life history of this cutworm is so limited that little can be said about it. What we know, however, applies about equally well to the other two species under consideration.

The moth does not appear to have been captured or reared earlier than July 28 in the District of Columbia. In cold rooms in confinement moths have bred out at intervals during the winter, and one was present in our rearing jars, and active when stimulated, February 2. It is evident that moths develop in the field as early as the last week of July and irregularly from that time, according to the state of the temperature.

The species is credited with being double-brooded, and of this there can be no possible doubt. It is more probable, however, that three generations are produced in the District of Columbia and farther South.

When fully matured the larvæ enter the earth to a very moderate depth, according to the writer's observation, and form, at least for the last generation or hibernating pupa, a tolerably compact, serviceable cocoon, moderately lined with silk and outwardly covered with sand or earth. The winter, according to Riley, is passed generally in the larval stage, but sometimes also as pupa or imago. Recent observations do not uphold this theory, since the climatic conditions are much the same in Missouri as in the District of Columbia and vicinity. In the latter locality larvæ have never been found hibernating, and it is probable that the pupæ would pass the winter under suitable conditions, but the imago often hatches out, as previously stated, at times during the winter, and it does not seem probable that all of the individuals which issue in cold weather survive cold spells.

NATURAL ENEMIES.

Mention has already been made of a *Tachina* fly parasite of the larva.

Limneria sp.—A larva was brought to this office June 13, 1899, by Mr. T. A. Keleher, who found it feeding upon tomato. It was at

this time only about one-fourth grown, and it was somewhat surprising to find that a parasite issued from it in a few days and spun up its cocoon June 18. The adult parasite issued June 26.

Capidosoma truncatella Dalm.—A *Prodenia* larva of this species found on tomato September 20, 1900, was noticed to be infested with this minute Chalcidid, which issued later.

REMEDIES.

The remedies are the same as for the variegated cutworm and similar species.

THE EUDIOPTA OWLET MOTH.

(*Prodenia eudiotpa* Guen.)

The moth of this species, until recently labeled in collections *Prodenia flavimediata* Harv., is nearly as often met with in the District of Columbia as the two preceding species, but until the past year the larva does not appear to have been so often observed attacking useful plants. It has not yet been identified with attack upon violet, but since it is so closely related to the other two *Prodenias*, and especially to *ornithogalli* Guen., from which indeed it can sometimes be separated only with difficulty, it may appropriately be considered in connection with the other two forms mentioned. During the year 1900 larvæ were several times taken on tomato, into the fruit of which they sometimes bore after the manner of the boll worm.

DESCRIPTIVE.

The moth.—The closeness with which this species approximates *ornithogalli* is such that it leads to the suspicion that they may be only dimorphic forms of the same species, a matter which could perhaps be satisfactorily determined one way or the other by rearing from the egg, an experiment which we hope to perform the coming season.¹ The differences, indeed, are much less striking than are those of the two common forms of *Laphygma frugiperda*. The most striking character is the brighter coloration of the fore-wings, the ground color of which is more or less ochreous. The body is lighter, with an ochreous tint particularly marked at the tufted extremity. The apex of the fore-wing is well marked with whitish, as is also a little area about the tornus. The oblique band which crosses the fore-wings from near the middle of the costa toward the tornus is wider and pale yellowish, and the space between this and the dorsum is variegated pale brown. The size is about the same as *ornithogalli*.

This moth is shown at figure 3, *a*, of Plate IV.

As to the validity of this species it may not be out of place to quote the language of Professor Riley in discussing these three species.

¹This rearing has since been made, both forms developing from a single egg mass. See Appendix.

Speaking of "*Prodenia commelinæ*" (= *ornithogalli*), he wrote (Papilio, Vol. II, p. 43):

With the well-known varieties of *Laphygma frugiperda* in mind, I have been particularly interested for a good many years in breeding this *Prodenia*, and I record here my belief, which will be the accepted belief in the future, that *flavimedia* and *lineatella* are one species not distinct from *ornithogalli* Guen. The larvæ, so far as I have bred material, are extremely variable and not separable, and the same may be said of the mature insects. They are more readily separable from the typical *commelinæ*, though doubts even as to their specific distinctness from it are justifiable.

In case *ornithogalli* and *eudiotra* should prove to be varieties, the former name would take precedence, as it was described first, although in the same publication.

The larva.—The general color of the larva of this species in its last stage is much darker than that of the two forms previously mentioned, the triangular spots in most individuals being velvet-black. The dorsal line is reddish-brown; the latero-dorsal stripe is bright canary-yellow, its upper fourth or third and lower sixth or eighth forming distinctly separable stripes within the main stripe, and inclosing a third duller stripe streaked longitudinally with undulating olive-brown; the lateral or stigmatal stripe just below this is a little narrower, and so closely streaked with black as to appear uniformly black except under a magnifier. The latero-ventral stripe is of about the same width as the lateral. It is light yellowish-brown dorsally, and darker brown below, mottled with white. The ventral surface of the body is olive-brown, greenish-olive medially, mottled with white.

The difference between the larva of this species and that of *ornithogalli* may perhaps prove to be of a varietal nature only.

The length of the larva (inflated) when fully matured is about one inch and three quarters (45^{mm}), and the width a little over a fourth of an inch (7–8^{mm}). An illustration of the larva, dorsal view, is given in the last object figured in Plate IV (fig. 3, *c*), the object above it (*b*) showing the lateral view of the penultimate stage.

DISTRIBUTION.

The distribution of this species appears to be the same as for the preceding, any difference that may exist, so far as our records go, being accountable for the fact that this form is liable to be confused with *ornithogalli* by those not perfectly familiar with both, as well as by the somewhat greater scarcity of the present species. In New Jersey *eudiotra* is credited by Smith with the same distribution as *ornithogalli*. It is common in the District of Columbia, and the moth is frequently taken at lights. It has also been reported at this office from St. Elmo and Falls Church, Va.; Kirkwood, Mo.; Texas and California, and it has been recorded from Massachusetts, New York, Dayton, Ohio (Pilate), and Nebraska.

RECENT OBSERVATIONS.

In recent observations this species has come under notice as follows:

July 20, 1899, a larva was taken feeding on the leaves of pokeweed, *Phytolacca decandra*, growing in the Department Insectary. This larva ceased feeding and entered the earth July 23, the moth issuing August 6.

August 10, 1900, Mr. Nathan Banks brought larvæ of this species from Falls Church, Va., less than one-fourth grown, feeding upon tomato. They fed most voraciously in confinement, and in three days had completed growth, entering the earth on the 13th and 14th of August, the adults issuing August 29.

August 16 Mr. Pratt brought a larva found at St. Elmo, Va., boring into tomato. As was to be expected, this individual was very much paler than normal, and the triangular dorsal spots were also pale and inconspicuous. This larva at once bored into a tomato when provided with one.

Larvæ were subsequently found and reared to moths on tomatoes growing in the District of Columbia. One of the larvæ kept under observation entered the earth August 31, and the imago issued September 15. Moths were obtained at lights in the city as late as the 31st of October.

Nothing can be found by the writer at the present time, in all the literature which has been consulted, concerning the biology of this species, and the same is true of our Divisional notes.

The larvæ, like those of the preceding species, have frequently been observed crawling about the grounds of the Department of Agriculture and elsewhere in the vicinity of the District of Columbia, and we have one record of the larva feeding on turnip, one of its feeding upon "bushberry," and another of attack on castor-oil plant.

REMEDIES.

For a consideration of the remedial treatment to be observed in the case of attack by this species the reader is referred to the article on the variegated cutworm.

THE FALL ARMY WORM.

(*Laphygma frugiperda* S. & A.)

The first occurrence of the fall army worm or "grass worm" on violets that appears to be recorded in our notebooks is dated August 9, 1897, when we received from Miss Louise Morris, Athens, Ga., the report that the species was injuring violets at that place, and that there were thousands of the caterpillars in the grass near by. The following month we received larvæ from Garrett Park, Md., where they were found on greenhouse violets.

As it is evident that this species has a fondness for violets among greenhouse plants, growers would do well to keep a lookout for it in times of its abundance on grasses and other outdoor plants.

A general account of this insect, with illustrations of the larva, pupa, and imago, was given on pages 78-85 of Bulletin No. 23 of the present series; and, as a more detailed account of it will shortly be published, further mention may be omitted for the present.

The remedies applicable to this species are the same as for the variegated cutworm, at least as far as the occurrence of the fall army worm in greenhouses is concerned. A consideration of remedies to be used when this species is destructive in the field was given in the bulletin cited.

WHITE GRUBS.

Several other common greenhouse pests besides those which have already received special mention are often injurious to various plants grown under glass, and are occasionally troublesome to violets by attacking their roots. Among these are white grubs and wireworms. Complaints of both forms of insects have recently been made, but unfortunately the species concerned in the injury have in no case been identified, it being a difficult matter to rear these insects from material which has gone through the mails, principally because they need the best of care and attention, and require as well a considerable period for their development, extending in some cases over a period of three years. Nearly every florist is familiar with white grubs, but he may not know that there are several hundred different forms of these creatures, each representing a different species of the family Scarabaidæ or Lamellicorns. Fortunately only a small portion of the white grubs are of prime importance economically, the remainder not attacking living plants. The destructive forms subsist upon roots under sod and about weeds and various cultivated plants, and most of these, the typical white grubs, belong to the genus *Lachnosterna*. They are brought into greenhouses in pots of earth, and occasionally in manure, but as a rule the species which breed in decomposing matter, such as manures, are much less destructive than the species of *Lachnosterna*. The different species can be distinguished from one another only by careful study, and for practical purposes it will not be necessary to consider this subject in detail in the present bulletin.

The species of white grub shown in the accompanying illustration, (fig. 20), may be taken as a type of this class of insects. The grub itself, illustrated at *a*, is of large size, of soft consistency, and white or slightly yellowish in color. The body is wrinkled, covered sparsely with fine hairs, and the head is brownish and armed with strong mandibles.

This, as well as other grubs of the same class, habitually rest in the curved posture illustrated. The parent beetle, shown at *a*, is a large

species, dark shining brown in color, and, like others of its kind, familiar to nearly everyone from its habit of flying into lighted rooms in late spring and early summer, where it buzzes and bumps about upon the ceilings until it drops sprawling to the floor. The antennae or feelers are jointed and terminate in a club composed of seven leaf-like plates, folded closely together when the beetle is resting and expanding somewhat like a fan when the insect is active. The club of the male antennae is usually considerably longer than that of the female. The form figured, *Lachnosterna arcuata*, is a Southern one, and common in a climate like that of the District of Columbia. Here these creatures occur from about the middle of April into June, being most abundant in May; hence the name of May beetles. Farther north they are more abundant in June, and are there called June beetles. They are familiar objects at electric lights in most cities.

The life history of a white grub of the genus *Lachnosterna* may be given in general terms as follows: The sexes pair soon after their first

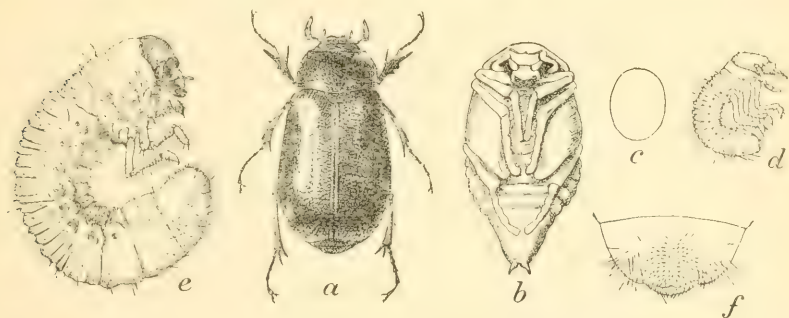


FIG. 20.—*Lachnosterna arcuata*: a, beetle; b, pupa; c, egg; d, newly-hatched larva; e, mature larva; f, anal segment of same from below. a, b, e, enlarged one-fourth; c, d, f, more enlarged (author's illustration).

appearance, whether in April or later in May or June. The females enter the earth and there deposit singly their rather large whitish or gray-colored eggs, one of which is shown in outline at *c* of the figure, each in a separate cell, and usually at a depth of from 2 to 4 inches. The grubs hatch and feed upon the roots of grasses and similar plants—first upon rootlets, and afterwards on larger roots—living in the earth, and slowly increasing in size for a period of two or three years. Transformation to pupa in a normal outdoor condition usually occurs from about the middle of June to September of the second or third year after hatching, the beetles developing in August or September of the same year. These remain in the earthen cells in which the pupal transformation took place until winter has passed, sometimes at a depth of a foot or a foot and a half below the surface, where protection from cold and frost is obtained.

Hibernation may occur in two stages of the larva and occasionally in a third, as well as in the beetle state, and some variation as regards the insect's life economy is to be expected in the higher temperature of a greenhouse.

White grubs are preyed upon by a host of natural enemies, including other insects, parasitic and rapacious, birds, mammals, and Batrachians. In the last class toads are the most efficient, and they are sometimes utilized for the purpose of destroying insects in greenhouses.

REMEDIES.

The habit of white grubs of passing the greater part of their existence underground and at a considerable depth renders it a matter of difficulty to reach them with insecticides. Against some forms bisulphide of carbon, kerosene emulsion, and poisoned baits have been used with some success. For use in greenhouses the best remedy, everything considered, is the poisoned baits. Of these, one of the best is the bran-arsenic mash, which has been mentioned in connection with remedies used against cutworms. In addition to the use of this mash, it is always advisable to pursue the cleanest of cultural methods, the same as has been advised against cutworms, which includes the avoidance of fresh soil which might contain these creatures, the keeping down of all grasses in the immediate vicinity of greenhouses, and particularly in the soil in the greenhouse itself. The use of fertilizers is also advisable, as it enables plants to resist insect attack at the roots.

Sterilizing the soil by means of heat or steam is also of value.

As manures are frequently infested by white grubs, and some of these are at times troublesome, it is well to exclude such forms as experience has shown contain an excess of these creatures—as, for example, horse manure. They can be identified readily by disintegrating the material, and chickens and other fowls could be utilized in destroying them before the manure is used in the greenhouses.

WHITE GRUB OF THE GREEN JUNE BEETLE.

(*Allorhina nitida* Linn.)

Complaints are frequently received from correspondents of injury by the larvæ of this species, but in most cases there are reasons to believe that the damage is really done by cutworms or some other insects, and the white grubs, on account of their large size and their habit of crawling about on the surface of the ground, are blamed for the misdemeanors of the other species.

An instance which was probably of this character was reported to this office November 21, 1898, by Mr. W. E. Pray, Kinkora, N. J., who sent specimens with report that this "grub-worm" was troublesome

in his violet houses. The larvæ were first noticed soon after the plants had been put in bed, and at this time they seemed to do very little if any harm, but the ground was described as being "kept well cultivated for two inches deep by their movements." As the plants grew the larvæ were stated to begin to feed upon the fibrous roots, and were so doing at the time of writing. They were also stated to devour the outside petals of the flowers which rested upon the ground and very frequently ate into the hearts of the flowers, rendering them unfit for shipment. Specimens of violets showing the alleged work of this species were received with the white grubs. A great number of the flowers were described as having been destroyed, and a remedy was requested.

From the nature of the description of the injury there seems to be little doubt that cutworms were the authors of the damage in the case above cited.

WIREWORMS.

The term wireworm is applied to numerous forms of elongate wire-like creatures, the larvæ of snapping beetles or "snap-bugs," beetles of the family Elateridæ. Many of these species are injurious to cultivated crops and are often troublesome in greenhouses to plants of various kinds, including violets. As with white grubs, however, and for the same reasons, the exact species causing this form of injury to violets have not been determined.

The writer has in mind one complaint made of the ravages of wireworms to violets at Arlington, Md., reported to this office November 25, 1898, by Mr. James K. Marks, jr., who stated that the insects were giving a great deal of trouble, a remedy being desired.

A common form of wireworm in the field and one that has been identified as occurring also in greenhouses is the species figured herewith, known scientifically as *Agriotes mancus* and popularly as the wheat wireworm. It was received during April, 1898, from Mr. Milan C. Moulton, York Corner, Me., with report that it was injurious in a greenhouse there, cucumbers being attacked when no other plants were in the house. In the illustration (fig. 21) *a* represents the

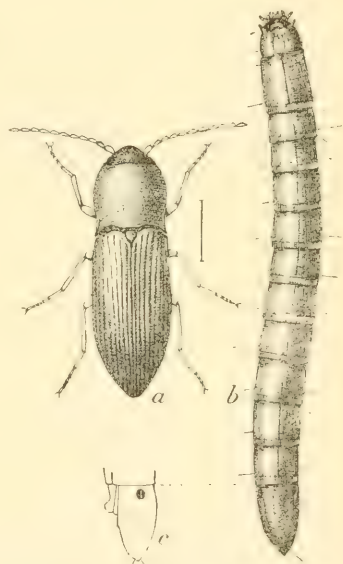


FIG. 21.—*Agriotes mancus*: *a*, beetle; *b*, larva; *c*, anal segment of larva in profile—about 4 times natural size (original).

beetle, four times natural size; *b* the larva or wireworm, and *c* the anal segment of the same in profile.

A large proportion of these wireworms are shiny yellow in color, and the present form is no exception, while many of the adults, like the species figured, are brown and covered with close brown or yellowish pubescence.

The life history of injurious subterranean species is in some respects similar to that of white grubs, the beetles being among the earliest spring arrivals, occurring in April and May, flying rapidly in the heat of the day.

The eggs are deposited by preference in moist places grown up with grassy vegetation, weeds, or corn, and the larvæ upon hatching feed, like the white grubs, upon the roots, developing slowly and requiring about the same period for the perfection of the life cycle—about two or three years. Like the white grubs, also, the wireworms transform to pupæ in autumn, and change to the beetle form takes place before winter, the beetles usually remaining in a quiescent state until their emergence the following spring.

In the warmer temperature of the greenhouse this life cycle might vary somewhat from the normal cycle out of doors.

REMEDIES.

Owing to the extremely hardy character of the larvæ, indicated by the hard, firm texture which has given them the name of wireworms, as well as to their subterranean nature, these insects are even more difficult to treat satisfactorily than the white grubs.

Of direct applications, poisons are of little value, but salt in large quantity has been used by some persons with success for many years, and has been reported to be one of the most effective applications that can be made. Strong brine, it should be stated, must be used with caution, as it sometimes destroys certain forms of plant life.

Different forms of salty fertilizers are also said to be of value, both as stimulants to the affected plants and as insecticides. Among these are kainit and nitrate of soda.

The sterilization of the soil, clean cultivation, and poisoned baits are also indicated, the same as for white grubs. In fact, where remedial measures are in use against either cutworms or white grubs, they apply about equally well to wireworms.

One of the best forms of bait to be used consists of slices of potatoes or other vegetables poisoned in the same manner as advised in the consideration of the variegated cutworm.

MISCELLANEOUS INSECTS INJURIOUS TO VIOLETS.

A perusal of available literature shows some additions to be made to the list of the different species of insects which have been treated in preceding pages in connection with their attack upon the violet, and some insects are also mentioned in the files of this office, which have not been recorded as attacking this plant.

"*Green Aphis*."—Two and probably more species of aphides affecting violets are known to growers, but only two have been identified specifically. These are the plum plant-louse, *Myzus mahaleb* Fonsc., which was treated on pages 52–59, Bulletin 7 of the present series, and *Rhopalosiphum dianthi* Schrank. The first of these was received November 19, 1898, from Mr. W. D. Philbrick, Newton Center, Mass., who stated that these plant-lice were usually noticed to be quite plentiful when the violet plants were first brought in under glass in the fall from the field where they are grown in the summer. This form is usually found on the underside of the large old leaves near the ground. During January and February, 1899, specimens were received from Mr. F. B. Boone, Charlottesville, Va., found on violets grown under glass. May 2, of the same year, Mr. Galloway brought specimens which were present upon violets, *Scrophularia* and *Capsella bursa-pastoris*, at his place.

A comparison of the nature of injury by the green aphides which attack violet and the brown or black aphis is made by Mr. A. F. Woods in a statement that the latter produces a marked stunting of the plants, while the former does little injury outside of distorting the flowers (Bul. 19, Div. Veg. Phys. and Path., p. 24, 1900).

Rhopalosiphum dianthi Schrank. was received November 21, 1898, from Mr. W. C. Pray, Kinkora, N. J., who sent two apterous specimens found upon violets at his place. These plant-lice were described as causing the flowers to turn white in spots by suction of the juices from the parts affected.

The "syringing," or, more properly speaking, spraying, to which violet plants are subjected two or three times a week to keep them free from "red spider," also serves to suppress or to at least keep down the number of aphides, and it is perhaps this remedy more than anything which has held in abeyance the so-called green aphides of violets.

A scale insect on violets.—A scale insect known as *Dactylopius virgatus* is on record as attacking violets (Insect Life, Vol. V, p. 247).

Butterfly caterpillars.—A considerable number of butterflies of the genus *Argynnis* subsist in the larval condition on wild violets, which is their normal food plant, and these and related species which attack wild violets are liable at any time to attack cultivated plants. Among related species which have similar habits is *Melitaea editha* Boisd.

The variegated fritillary (*Euptoicta claudia* Cram.).—One of this group of butterflies, the Nymphalinae, is the species above mentioned. July 2, 1900, we received a number of caterpillars of this species from Mr. Willie A. Toole, Baraboo, Wis., with report that they were found on young pansies and were numerous enough to cause some damage. Writing again October 27 our correspondent stated that this species was very plentiful during the year, more so than in the preceding season, and expressed the opinion that if it continued to increase as it had done it might become a serious pest. During the past season the butterflies paid in part for what injury the caterpillars had accomplished, in the fertilization of the pansies—bumblebees, the insects which usually bring about this result, having been unusually scarce.

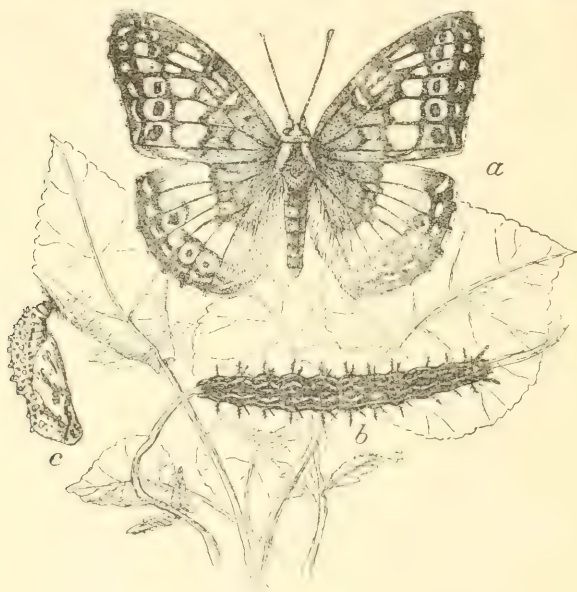


FIG. 22.—*Euptoicta claudia*: a, mature butterfly; b, caterpillar; c, pupa—all natural size (original).

A full account of this species has been given by Dr. S. H. Scudder in his "Butterflies of the Eastern United States and Canada" (Vol. I, pp. 519-527) where the different stages are fully described and figured, and other obtainable facts are detailed. The life history, however, is still somewhat incomplete. A shorter account is given in Dr. W. J. Holland's "Butterfly Book" (pp. 99, 100).

This butterfly varies in the depth of markings as well as in size, the wing expanse being from an inch and three-fourths to two inches and three-fourths. The upper surface is dull ferruginous or pale brown, shaded on the inner moiety with darker brown, and beautifully marked, lined, and spotted with black, forming a pattern more or less like that depicted in the illustration at a.

The caterpillar (*b*) is of cylindrical form, reddish or yellowish red in color, and marked with two brown lateral bands and a series of zigzag white interrupted lines upon the back. There are six rows of short, black, branching spines upon the body. The first thoracic segment bears a pair of these spines nearly twice as long as the remainder.

The chrysalis or pupa is nearly white in color, marked with dark brown and black spots, the dorsal surface being ornamented with golden tubercles arranged in rows. Altogether it is a most beautiful object. It is illustrated at *c*.

This species has a wide distribution, extending from Long Island and Connecticut southward, and westward from Virginia over practically the entire continent and into South America, where conditions favor its development.

It is recorded to feed upon the passion flower.

Oligia grata Hbn.—December 6, 1900, Mr. G. W. Morris, Poin-dexter, Va., wrote that this species of Noctuid was concerned in injury, with the spotted cutworm (*Noctua c-nigrum*), to violets grown in his vicinity. Both blooms and leaves of the plants were eaten.

The red-banded leaf-roller (*Lophoderus trifurcata* Walk.)—This species was reared from larvæ found feeding upon violets in the District of Columbia, August 13, 1897. It is a common species of the family Tortricidæ, and infests, besides numerous field and garden crops and fruit trees, rose, chrysanthemum, Lobelia, honeysuckle, and some other ornamental plants.

Unknown Tortricid.—November 7, 1898, we received injured specimens of a small Tortricid larva from Mr. H. B. Boone, Charlottesville, Va., with the statement that the species was troublesome to violets at that place. A remedy was requested to expel them from the beds in which they were lodged.

A leaf-miner on violets.—During September, 1885, a few larvæ of a leaf-miner were noticed on violets in Virginia near the District of Columbia. The larva was obviously coleopterous and evidently belonged to the family Chrysomelidæ, subfamily Halticini. It mined a large blotch on the upper side of the leaves. Unfortunately the species was not reared.

The yellow bear (*Spilosoma virginica* Fab.)—The yellow bear is of very common occurrence in greenhouses but fortunately for the florist it is more abundant in the field, orchard, garden, and vineyard, and as it does not appear to prefer any particular greenhouse plant, attack is usually so distributed that injury is not felt if careful watch be kept for the appearance of these larvæ so that they may be promptly destroyed.

June 27, 1900, Mr. Dorsett reported this species as occurring on violets in his greenhouse at Garrett Park, Md. A number of specimens were brought to the writer from which the moths began issuing

July 19. On the same date we obtained moths from larvæ received during June from Mr. J. H. Heard, Montreal, Ga., where they were found attacking cabbage. August 8 another lot of larvæ were received from Mr. Dorsett. It was also observed on two earlier occasions in July in 1898 and 1899.

Arctia nais Dru. (!)—Specimens of the larvæ of what were believed to belong to this Bombycid moth were received November 10, 1898, from Mrs. H. B. Boone, Charlottesville, Va., with report that they had been found in violet beds at that place.

Injury to violets by myriapods, sow-bugs, etc.—Different species of myriapods, or thousand-legged worms, and sow-bugs or wood-lice have been reported as occasioning injury to cultivated violets.

The myriapods are not positively known to be the cause of original damage to plant life, but it is not impossible that they assist in injury after the plant has become weakened by the attacks of true insects, such as cutworms and other caterpillars. Myriapods are scavengers by nature, and the product of damp and neglected soil containing an excess of decomposed vegetable matter or soil humus.

Two species have recently been identified in connection with injury to violets, and determined by Mr. O. F. Cook, of this department, as *Orthomorpha gracilis* (C. L.) Koch, a form found in troublesome numbers in and about the District of Columbia, and *Campodes flavicornis* (C. L.) Koch. The latter was reported January 14, 1901, by Mr. James K. Marks, jr., Arlington, Md., to be found in the ground about violet plants, which seem to die as soon as these thousand-legged worms congregate about them. It was stated that these creatures ate the small white roots of the plants.

In the American Florist for December 14, 1893 (Vol. IX, p. 448), the late Dr. C. V. Riley published a short letter in answer to correspondence concerning the occurrence of a myriapod identified as of the genus *Julus* said to be injuring violets, locality not stated.

A common species of sow-bug, *Armadillidium armadillo* Linn., occurring in the District of Columbia and vicinity, has been reported to do occasional damage to violets.

A species of sow-bug was received at this Department in 1890 from New Orleans, La., with the statement that it was destructive to the flowers of violets and pansies at that place and the present year, March 26, 1901, Miss N. L. Horlbeck reported injury to violets at Charleston, S. C.

Sow-bugs or pill-bugs, as they are also called, are not true insects, but crustaceans, but as they as well as the myriapods are classed by florists and the public generally with true insects, they may properly receive passing mention in this connection.

Injury by sow-bugs is apt to be exaggerated in many instances, still these creatures are often troublesome in greenhouses and in similar

locations. Ordinarily they can be kept in check by poisoned baits, the same as those used against cutworms, or still better by distributing about the places which they infest slices of potatoes or other vegetables that have been dipped in a solution of Paris green prepared at the rate of about 1 pound to 100 gallons or a little less of water.

Aphodius granarius Linn.—March 15, 1901, Mr. A. F. Woods showed the writer specimens of this common dung beetle with report that it occurred in great abundance in a violet house at Takoma Park, D. C. He stated that in a small corner of the house hundreds of thousands of the beetles could be seen crawling and tumbling over each other. So far as we know, this dung beetle agrees with others of its kind in being innoxious. There is, however, a recorded instance of reported injury, that by Prof. C. H. Fernald (Bul. 1, Hatch Experiment Station, Mass. Agric. College, p. 3). Specimens of the beetles were received from Lancaster, Mass., with the statement that they had been found destroying seed corn in the ground before it had sprouted. This is one of our commonest dung beetles, and its occurrence in the violet house was, of course, due to the presence of manure in which the species breeds. It has been surmised that from the known habit of this species feeding in part on fragments of undigested grain that it might, under favoring conditions, transfer its attentions to seed corn in the hill, but this seems somewhat doubtful.

ROSE BUD-WORMS AND LEAF-TYERS.

Among the many insect pests which the florist has to combat in the cultivation of roses grown under glass are several small species of bud-worms and leaf-tyers, the larvæ of moths of the family Tortricidæ. Of these some of the most important will be considered.

THE ROSE BUD-WORM.

(*Penthina nimbatana* Clem.)

RECENT INJURY.

During the past summer the attention of the writer was called to the work of the larva of *Penthina nimbatana* Clem. on hothouse roses through Messrs. Erwin F. Smith and P. H. Dorsett, of this Department. July 8 word was first received of injuries to roses in the green-houses belonging to Mr. Alexander Garden at Anacostia, D. C. The insect was in the larval condition when received, July 11, and remained so, feeding until July 13, when one or two showed signs of approaching transformation. The roses were being injured by the work of the larva on the foliage, buds, and flowers, the buds especially suffering.

Rose appears to be the only known food plant of this larva, and heretofore, it appears, it has never been recorded as attacking any portion

of the plant other than the leaves. In our Divisional notes, however, there is a record of the rearing of the moth, December 22, 1896, from larvæ found December 15 folding leaves and injuring buds of roses in a hothouse in the District.

PUBLISHED RECORDS.

The first record that the writer finds of the food habits of this species was published in 1881, a note by Mr. D. W. Coquillett of four lines, descriptive of the larva and its food plant, wild rose, *Rosa blanda* (Tenth Rept. State Entom. Ill., 1881, p. 153).

Mr. C. H. Fernald in his Catalogue of the Tortricidæ of North America, published in May of the following year (Trans. Amer. Ent. Soc., Vol. X, p. 31), mentions rose as a food plant. In the same year, 1882, Mr. Coquillett, in comparing the larva of this species with that of *Cateveia rosaceana* Harr. (11th Rept. State Entom. of Ill., p. 12), states that they are utterly indistinguishable from each other in certain individuals, and makes the further remark that *nimbata* was reared by him only from *Rosa blanda*. "It binds three or more of the terminal leaflets together for a habitation, and there appears to be only one brood produced in one season."

The next year the same writer gives a brief description of the larva in Papilio (Vol. III, p. 101). Larvæ "were taken the first week in June; they pupated a few days later, and the imago issued June 20 and 21."

During the same year the late Dr. J. A. Lintner published a note on injuries by this species to rose plants in greenhouses (Count. Gent. Mar. 1, 1883, p. 169). This note was in response to inquiry from a correspondent, "D. J. G.," Scarsdale, Westchester County, N. Y., dated February 7 of that year.

In his Fourth Report as Entomologist of the State of New York (1888, pp. 213-215), Dr. Lintner gives a more extended account of this species, with illustrations of the moth.

DESCRIPTION AND DISTRIBUTION.

The parent insect is a small moth of the family Tortricidæ. It is shown in the accompanying illustration (fig. 23, *a*). The general color is brownish gray, the outer portion of the fore-wings and the under surface of the hind-wings being lightest. The inner portion of the fore-wings is dark brown in color, mottled with white, black, and light purple spots, the prevailing pattern being about as indicated in the figure. The wing expanse is about five-eighths of an inch (16^{mm}), and the length of the body is about half as long.

This species has a rather wide distribution, as the following list of localities, based for the most part on outdoor occurrences, shows:

Maine; Massachusetts; Albany, Scarsdale, and elsewhere in New York; Pennsylvania; District of Columbia; Woodstock and elsewhere in Illinois; Wisconsin.

THE LARVA AND PUPA.

The earliest stages of this species do not appear to have been studied. The full-grown larva is shown at *b* of figure 23. The head and cervical shield are shining dark blackish brown, verging to black in the outer portions, the three pairs of forelegs and two lateral marks on the first thoracic segment are dull black. The remainder of the body is rather bright, clear apple green in color, which means that the spiracles, except on the first thoracic segment, the piliferous warts, and the anal plate are all concolorous. The length of the mature larva when fully extended is a little less than five-eighths of an inch (14-15^{mm}).

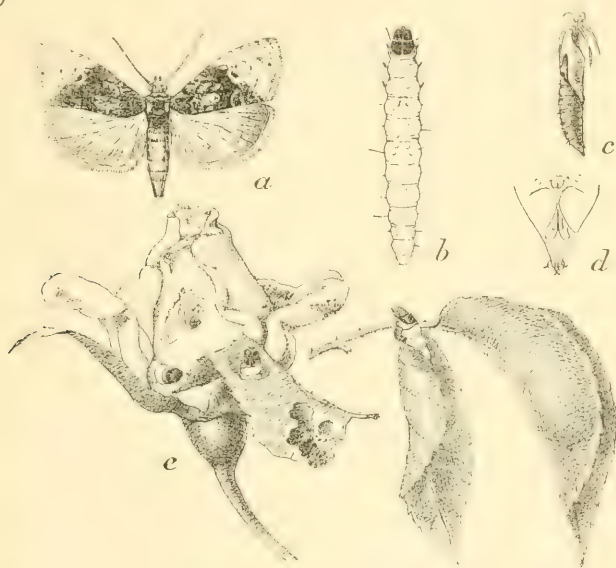


FIG. 23.—*Penthina nimbata*—*a*, moth; *b*, larva; *c*, empty chrysalis skin; *d*, terminal segment of pupa; *e*, rosebud, showing larva at work; *f*, leaves folded by larvæ—all twice natural size, except *d*, which is greatly enlarged (original).

At *c* and *d* of the illustration the pupa is shown, *c* representing the empty chrysalis skin after the escape of the larva, and *d* showing the character of the anal segment. The length is nearly three-eighths of an inch (8^{mm}), and the color is light brown.

At *e* of the figure the manner of work of the larva on an unopened rosebud is illustrated, and at *f* two leaves are figured as folded by the larva. The leaves of the rose are joined together after the manner of the larvæ of this group of insects by silken threads and the larva lives within the case thus made, feeding upon the leaves of which it is composed, and later leaving it to attack others.

LIFE HISTORY.

The life economy of this rose pest has not been fully investigated. The parent moth, according to Lintner, who has observed the species

in New York State, and from whose writings (l. c.) the following account of the life history is in the main compiled, appears in ordinary seasons in the vicinity of Albany about the middle of April. Its eggs are laid at night and presumably on the terminal leaves of rose bushes when they are pushing out from the buds. The caterpillar or larva, after hatching, begins by binding together the margins or surfaces of a folded leaf. With an increase of size the leaf, partly eaten and opened out by its rapid growth, is abandoned for another, or the larva selects two contiguous leaves and fastens them together. This habitation in turn, with the more advanced growth of the creature, is deserted for still more ample quarters, which it finds among several of the terminal leaves or in the unopened buds, as has been shown by recent observation in the District of Columbia.

Larval growth is rapid and at each successive molt the papillæ or piliferous warts and the hairs proceeding from them become more conspicuous. By the end of May the larvæ have attained full maturity, cease feeding, and are then believed to drop to the ground to undergo their final transformations among the dead leaves. The reason for this belief is that the pupæ have never been found among the folded or fastened leaves on the rose bushes.

The period of pupation is about nine or ten days. The moth of the first generation has been observed abroad at Albany as early as June 2. Eggs are laid for a second generation and the new operations of the caterpillars are soon to be seen and are extended into July. Dr. Lintner expresses the opinion that there is possibly a second generation,¹ since the transformations among insects of this class are quite rapid and several generations are of common occurrence in many species. The latest date recorded near Albany was July 25.

The fact of our rearing this insect to the adult from larvæ taken in December would seem to indicate that there may be three, or perhaps even four, distinct generations developed each year, under glass at least, in a climate like that of the District of Columbia.

As the name of rose leaf-tyer is preoccupied by *Penthina cyanana*, which will presently receive mention, rose bud-worm is proposed as a suitable appellation for this insect.

A PARASITIC ENEMY.

One larva received from Anacostia was seen to be parasitized, the parasites being noticed in the larval condition from July 11 to 13. The adult parasites began to issue July 15 and were identified by Mr. Ashmead as *Eulophus cyriades* Walk., a Chalcidid fly.

¹ In speaking of the different generations, Lintner mentioned the first appearing moths as one brood, and the first generation hatched during a year (which the writer considers the first generation) as a second brood, and the second generation as the third brood.

REMEDIES.

This species is amenable to the same remedies as the greenhouse leaf-tyer, considered in the initial article of this bulletin.

The presence of the caterpillars on roses is so obvious as to be easily detected, and all that is necessary in many cases when they are found in the leaves is to crush them between the thumb and forefinger. If the greenhouse is not fumigated the only remedy after the caterpillars have attacked the buds is to cut off the buds and burn them, or destroy them by crushing under foot.

Owing to the concealed manner of life of the larva it is doubtful if insecticides would be of much value when the insect is found on roses in gardens, hence hand methods must be resorted to.

The larvæ of a number of other moths, mostly Tortricidæ, attack roses in much the same manner as the rose bud-worm. Some of the best known of these may be briefly mentioned.

THE ROSE LEAF-TYER.

(*Penthina cyanana* Murtf.)

A species closely related to *Penthina nimbata* is *P. cyanana*, which was described by Miss Murtfeldt in 1880 (Amer. Ent., Vol. III, pp. 14-15). The habits of this species do not appear to differ materially from those of *P. nimbata*. It is more abundant on roses growing in the open, but according to Mr. G. C. Davis it also attacks roses in greenhouses. Of its injuries at Kirkwood, Mo., Miss Murtfeldt wrote that it was occasionally so abundant as to devour or mar fully 20 per cent of the rosebuds, especially of white or light-colored varieties.

Among the notebook records of the Division of Entomology this is stated to have been found by the late Dr. Riley in injurious numbers on his roses at Washington during the summer of 1879. July 6 of the next year he received rosebuds containing larvæ, which were reared to the adult, from Mr. Henry Plumb, Pleasanton, Kans.

This species was found at work on roses at Alexandria, Va., by Mr. T. A. Keleher, of this office, in July, the imago issuing in the middle of that month.

The recorded distribution of this species comprises portions of the states of Missouri, Kansas, Pennsylvania, and Michigan, and to this list may be added the District of Columbia.

As in manner of life all these rose pests are similar, the remedies to be applied are the same.

THE OBLIQUE-BANDED LEAF-ROLLER.

(*Cacaccia rosaceana* Harr.)

One of the most important of the leaf-rollers, from the economic point of view, if we consider its injuries to all its food plants, is

Cacæcia rosaceana. This is a well-known enemy of all sorts of fruit crops of the family Rosaceæ, as well as of several other orders, and is treated in most popular works on agricultural entomology.

Specimens of pupæ and adults of this species were received from Mr. S. S. Wilson, Libonia, Pa., with the statement made in an accompanying letter dated May 3, 1898, that it was received by him in a shipment of roses from a firm in Ohio, and that, on examining the roses, larvæ and chrysalides were found, and many of the leaves of the plants were eaten away.

THE ROSE LEAF-FOLDER.

(*Cacæcia rosana* Linn.)

This is an introduced species which attacks roses, but is not, so far as the writer is aware, particularly troublesome, at least in greenhouses. It is very likely to become injurious, however, at any time. It is figured and described as an enemy of currants by Messrs. Comstock and Slingerland (Bul. XXIII, Cornell Univ. Expt. Sta., pp. 119-121), and has been stated by Dr. Lügger to attack also the apple, wild rose, raspberry, hazel, hawthorn, and gooseberry (Fourth Annl. Rept. Entom. State Expt. Sta. Univ. Minn., 1899, p. 228).

OTHER LEAF-ROLLERS.

A short notice of injuries by the fruit-tree leaf-roller, *Cacæcia argyrosipila* Walk., to the buds of roses in greenhouses was published in Insect Life (Vol. III, p. 19).

To this list must still be added, as species that are known to attack roses, and are hence likely at any time to invade the greenhouse and assume the bud-destroying habit, several other Tortricids, among which may be mentioned the grape-berry moth, *Eudemis botrana* Schiff., *Platynota flavedana* Clem., *Tortrix albicomana* Clem., *Cenopsis petti-tana* Rob., and *reticulatana* Clem., as also *Lophoderus trifera* Walk., elsewhere noted as a violet insect.

FULLER'S ROSE BEETLE.

(*Aranigus fulleri* Horn.)

Various greenhouse plants, and roses in particular, are often severely injured and destroyed, unless remedial measures are adopted, by a moderate-sized, obscure, brown or gray snout-beetle, commonly known as Fuller's rose beetle, *Aranigus fulleri* Horn. Prior to the year 1874 this species does not appear to have been recognized; in short, its technical description was not published until the Centennial year. At about that time and soon afterwards, as well as at intervals later, it has attracted considerable attention on account of its ravages

on roses, camellias, geraniums, and other ornamental plants in different portions of the country, particularly in the Eastern States, and more especially in New Jersey, New York, and Massachusetts. During the last two years this species has been troublesome to roses and carnations, especially in portions of New York and Wisconsin, and in lemon groves in California as well as in Hawaii.

This insect is destructive in both of its active stages, doing most damage as a larva, when it lives in the soil and feeds upon the roots of its food plants, the beetle practically confining itself to the foliage, flowers, and buds of the plants which it attacks. Although preeminently a greenhouse pest, in California, particularly in the southern portion, groves of orange and lemon as well as other trees sometimes suffer much injury.

DESCRIPTIVE.

The beetle.—The adult of this insect is one of the so-called scarred snout-beetles (of the family Otiiorhynchidae), and was given its specific name in honor of the late A. S. Fuller. It measures from a quarter to nearly three-eighths of an inch in length, and is of the form shown in figure 24 at *c* and *d*. The snout is quite short and scarred at the sides of the mandibles. The head is white, and the abdomen is ovoid. The color is dark dirty brown, and the entire body, including the legs, is lightly covered with gray or pale-brown scales. On each side of the elytra there is a whitish diagonal line.

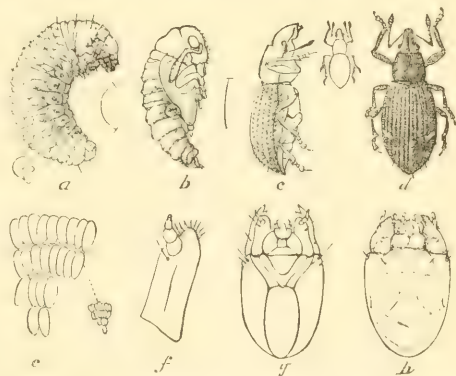


FIG. 24.—*Aramigus fulleri*: *a*, larva; *b*, pupa; *c*, beetle, outline side view; *d*, same, dorsal view, the outline between them showing natural size; *e*, eggs enlarged and natural size; *f*, left maxilla with palpus; *g*, lower side of head of larva; *h*, upper side of same enlarged (from Riley).

The egg.—An egg mass is shown in the illustration at *e*, greatly enlarged, the natural size being indicated at the right side. An individual egg measures about 0.9^{mm} in length and about one-quarter that in width. It is smooth, soft, and of a pale translucent yellow. The normal form is ellipsoidal, but great variability occurs from the close compression of the eggs, as they are deposited in rows.

The larva is shown in the illustration at *a*. It measures about 8^{mm} in length, is milky white in color; is destitute of organs of locomotion, and when in resting position is arched usually about as shown.

At *f* the left maxilla of the larva with its palpus is shown; *g* illustrates the under side of the head, and *h* represents the upper side, these last three figures being much magnified.

The pupa is about 7^{mm} in length, and of the same milky white color as the larva. It is shown, side view, in the illustration at *b*.

DISTRIBUTION.

At the time this species was described in 1876 (*Rhynchophora* of America North of Mexico, pp. 94, 95) it was known to have a wide distribution, stated to be "from New Jersey to Montana." At the present time it is known to occur from Maine to California, and has been reported at various times as being destructive in greenhouses in a large number of states. The habit it has of feeding in the larval state in the earth about greenhouse plants makes it peculiarly susceptible to transportation with the plants from one locality to another, and it is quite remarkable that it does not cause more destruction than is reported.

The first observed specimen of this insect appears to have been received by Mr. A. S. Fuller from Montana, and as the only other species of the genus *Aranigus* is American, it seems probable that, in spite of the fact that the insect lives almost exclusively indoors, it is native to America, although probably of neotropical origin. It was probably introduced from Mexico.

A list of localities follows: Bucksport, Me.; Cambridge, Boston, Worcester, Mass.; New York, Rochester, Little Falls, Poughkeepsie, Albany, Long Island, N. Y.; Madison, Summit, Jersey City, Union County, N. J.; Baraboo, Wis.; Mt. Airy, Griffin, Ga.; Sandwich, Ill.; Montana; National City, San Francisco, San Diego, Los Angeles, Fullerton, Cal.; Brantford, Stewarton, Ottawa, Canada, and Hawaii.

Concerning the distribution and periodicity of attack of this species, Mr. Schwarz of this office has pointed out (*Proc. Ent. Soc. Washington*, Vol. III, p. 145) that the insect does not occur so far as we know out of doors, either in Montana or in neighboring states farther south, although it is known to live outdoors in California.

If it could be proved that it lived in Montana originally, we have a case of rapid diffusion eastward analogous to that of the Colorado potato beetle, the weevil having spread to the Eastern States only a few years after that Chrysomelid. There is this difference, however, that the latter became disseminated mainly by flight, and the former, a wingless insect, through the agency of man.

RECENT INJURY.

March 15, 1900, Mr. Willie A. Toole, Baraboo, Wis., sent specimens of the larva of this beetle with the information that the insect was very troublesome in greenhouses around the roots of rose-scented geranium. They first eat the fine roots and then the larger ones, and when they get through with the plant there is nothing left of the roots

but a few stubs. They appeared to prefer geranium to any other plant growing in houses there, and they always came under observation in winter. The species was kept in check to a considerable extent by turning the plants out of their pots and picking out such grubs as could be seen and killing them, and by digging up and picking out the grubs from the dirt in the benches.

Mr. C. L. Marlatt of this office informed the writer that this species caused injury in lemon groves near San Diego, Cal., during July, 1900, and that in that portion of the country it is known as an occasional pest, having been established there for a number of years.

A similar report of injury in the same locality was received from Mr. G. P. Hall, April 19, 1899.

OCCURRENCE IN THE HAWAIIAN ISLANDS.

During February, 1901, we received specimens of this species from Mr. Albert Koebele, at present stationed at Honolulu, H. I., with notes upon its habits. These specimens have been compared with authentically determined *Aranigus fulleri* by the writer, as well as by Mr. Schwarz and Mr. Charles Fuchs, and there is no doubt of their identity. It seems that the species is known in Hawaii as the Olinda bug, and has been described by Mr. V. R. Perkins as *Pandamorus olindæ*. Some notes are furnished by Mr. Koebele, which bear upon the insect's life economy. Its presence has been frequently noticed upon trees as well as upon Hilo grass. Many trees of Java plum recently planted have been seen by Mr. Koebele with every leaf eaten off, and some have died from the effects of the beetle and Hilo grass combined. The insect appears to be most numerous along the border of forests, and is found from the seashore as high up as 5,000 feet elevation. Seven years prior to the date of writing the beetle was seen from Paia, where it was destructive to roses and garden plants generally. Our correspondent believes that it must have been present on the islands long before it became prominent as a pest, and he as well as Mr. Schwarz, the writer, and some others are inclined to the belief that it is an introduction from Mexico—Mr. Koebele believes probably from Acapulco, but does not state reasons.

Larvæ have been found under stones, and in large numbers also in galls produced by Tortricidæ.

HISTORY AND LITERATURE OF THE SPECIES.

Fuller's rose beetle appears to have been first brought to notice as a pest in the year 1879, when Peter Henderson published a four-column illustrated article concerning it in the "Gardeners' Monthly" for March of that year (pp. 86, 87).

This species furnishes an interesting example, analogous to that of the so-called black aphid of the violet, of how long an insect can do

extensive damage before public attention is drawn to its ravages or even to its identification. In Mr. Henderson's article he states that by correspondence with rose growers in six different states, and from personal observations, he had been forced to the conclusion that, in a large majority of cases where cultivation of roses during the winter proved unprofitable, the trouble was traceable alone to the ravages of this rose beetle. Owing to the small size and inconspicuous appearance of the beetle, and its habit of shunning the daylight and concealing itself under the leaves, as well as to the subterranean habits of its larva, its presence is not apt to be noticed by any except the most observing, or by persons who have had experience with it. The account in question includes, besides mention of injury by this species at Madison and elsewhere in New Jersey in the vicinity of New York City, a letter from Dr. Riley giving in condensed form what was known at that time concerning the insect's history, classification, distribution, and biology.

This article was followed by a more extensive one by Dr. Riley in the same publication for October (pp. 310, 311), republished from the *Scientific American* of August 30, 1879 (p. 129), these last two accounts including the illustration used in the present article. All of this matter was brought together in Dr. Riley's report as Entomologist for the Department of Agriculture for 1878 (Nov., 1879, pp. 255-257), technical descriptions of the immature stages being added. Injury at that time was most noticeable to roses and camellias. In the Report of this Department for the following year (pp. 250, 251) Professor Comstock furnished a few notes on the destructive occurrence of this insect at San Diego, Cal., in 1879, adding some unrecorded food plants and making mention of a wireworm found preying upon the larvæ.

An interval of four years elapsed before injury by this species was again noticed, at least so far as published records go. In November, 1883, we received complaint from Worcester, Mass., of injury to *Azalea* and *Cissus* (Report Dept. Agric. 1884, p. 414).

In December, 1884, injury was complained of to Dr. Lintner by extensive rose growers at Poughkeepsie (2d Report State Entom. N. Y., 1885, pp. 142-144). Dr. Lintner states that this species was first brought to his notice in 1874 because of injury to camellias and other foliage in conservatories at Albany, N. Y. The same writer had an article in the *Country Gentleman* of February 3, 1887, based upon injuries of this rose beetle at Bucksport, Me.

In 1889 Mr. Coquillett reported this species to be injurious in Los Angeles County, Cal., where it was mistaken for the plum curculio. It was very destructive at that time to the foliage of oak, camellias, palms (*Washingtonia filifera*), *Canna indica*, and several other plants.

The following year a short account of this species and its occurrence in California was given in the Annual Report of the State Board of

Horticulture of California for 1889 (1890, pp. 227, 228). An account by Dr. James Fletcher, in his report as entomologist and botanist of the Dominion of Canada, 1889 (1890, pp. 88-90), appeared at about the same time. Injury was noted at Stewarton and Ottawa, Canada, roses having been much injured. Begonias and lilies were also attacked. Dr. Fletcher also published an account, with original illustrations, in the report of the Entomological Society of Ontario for 1890 (1891, pp. 62-64).

In the year 1894 Mr. John G. Jack (Trans. Mass. Horticultural Soc. for 1894, p. 147) mentioned this species in connection with injury to primroses in the vicinity of Boston, Mass.

Brief mention of injury to carnations is given by Mr. F. A. Sirrine in the American Florist for March 3, 1900 (p. 913). Damage was noticed at Little Falls, N. Y., in October of 1899, and followed the removal of roses from the greenhouse in which the carnations grew.

There are several other notices of this species in addition to those which have been mentioned, but a few of these are not accessible, and others add little to our knowledge of the insect or its habits.

DIVISIONAL RECORDS.

Of reports of injuries other than those that have been already cited, the following are on record in the office, each communication which will be mentioned having been accompanied by specimens:

December 5, 1879, information was received from Mr. E. J. Wickson, San Francisco, Cal., of injuries by this species in orchards and gardens.

November 30, 1883, Dr. C. W. Minot, Worcester, Mass., wrote that this insect was found in greenhouses, and that its favorite food plant was Azalea; but Cissus and "inch plant" were also attacked. It was noticed by our correspondent that the beetles were to be found during the middle of the day perched as high as possible on the plants which they infest, and that they seek concealment upon the slightest disturbance. They fed upon the new shoots and tender leaves, and when a plant was permitted to stand alone they would frequently trim off the new shoots as fast as these appeared. The beetles disappeared about the first of January, a new brood replacing them in the spring.

December 31, 1889, Mr. A. W. Orr, Sandwich, Ill., wrote that the beetles were doing great havoc in greenhouses; they were described as gorging themselves and then crawling to the axils of the leaves or branches.

June 13, 1890, Mr. J. N. Harris, Griffin, Ga., stated that the beetles ate rose leaves and those of cape jessamine, stripping the bushes in a short time.

September 26, 1892, Messrs. George R. Hinde & Co. wrote that this species was becoming a pest at Fullerton, Orange County, Cal., by

eating the foliage of young nursery trees of the citrus group; the beetles were found on apricot, pear, and other trees, and attack on persimmon was noticed. Our correspondents observed that the beetles concealed themselves behind or between the leaves, or in other retired places, and when disturbed suddenly dropped to the ground and feigned death to escape observation, which they were easily able to do, owing to their color bearing so close a resemblance to the dry soil.

September 10, 1896, a communication was received from Mr. David A. Horton, National City, Cal., that the insect was depredating on orange in that vicinity.

SUMMARY OF FOOD AND OTHER HABITS.

In addition to roses this species, as has been previously related in treating of its recorded history, feeds upon geranium, Hibiscus, Dracæna, orange, lemon, cape jessamine (Gardenia), Java plum, Achyranthes, Abutilon, Plumbago, Azalea, "Cissus," "inch-plant," carnations, Begonias, lilies, primrose, Hilo grass, oak, camellia, palms, and canna. Tea roses appear to be particularly susceptible to attack, and geranium seems to be preferred next after roses. The beetles are of nocturnal habit, feeding so far as known only after dusk. During the day they are generally quiet, resting in more or less concealment under or among the leaves of their food plants or clinging to the twigs or smaller branches in such positions as not to be readily observed. They are quite active at night and feed voraciously. When disturbed they "play 'possum," after the manner of many other Coleoptera, and particularly beetles of the same family, by dropping to the ground and drawing their legs and antennæ tightly to their bodies. As they often remain motionless for a considerable time and as their color is so very similar to that of the earth about their food plants they readily escape notice. They feed principally upon the leaves, but their greatest injury is accomplished by severing the leaves more than by the quantity of foliage consumed.

The life history of the insect as worked out at this office several years ago is approximately as follows:

The eggs are deposited in flattened batches consisting of several contiguous rows, each batch containing from ten to sixty eggs. The female, as in another species of the same family, which has been treated in earlier bulletins (see account of *Epicærus imbricatus* in Bulletin 19, pp. 62-67), has the habit of secreting her eggs by thrusting them between the loose bark and the stem, especially at the base just above the ground. In upward of twenty batches examined the eggs were found to have been thus concealed, either between the loose bark, as described, or in some similar crevice. More rarely they are deposited upon the ground between the earth and the main stem of

the plant, and the eggs adhere so firmly together, and to the place of deposit, that they are not so easily seen and are also with extreme difficulty detached. The eggs observed required about a month to hatch.

The newly hatched larva, which is pale yellowish in color with light brown mouth-parts, is quite active, and upon hatching burrows immediately into the ground, where it soon acquires a bluish hue.

The larval period does not appear to have been ascertained, but it is with little doubt at least one month, and perhaps two or three more, this stage being passed entirely in the ground, where the pupa state is also assumed. As this species lives by preference, at least in most of the United States, under glass, there can be no great regularity in the duration of the periods of transformation. The insect may, in fact, be found in all stages during the winter and early spring months, injury appearing to be most noticeable in December.

NATURAL ENEMIES.

A single carnivorous insect appears to have been recorded as preying upon the larvæ of this beetle, this observation having been made in the rearing cages at this Department in 1878. The insect was a wireworm, the larva of a click-beetle, and was somewhat doubtfully referred to *Drasterius amabilis* Lec.

Toads are frequently found in greenhouses, and sometimes are purposely put in such places to prey upon destructive insects. They are known to feed upon insects related to this rose beetle, and probably feed upon the species in question.

Natural enemies that have been observed by Mr. Koebele in Hawaii include the mina bird and mongoose.

METHODS OF CONTROL.

The beetles are so long-lived and hardy that it is difficult, if not impossible, to destroy them by the use of ordinary insecticides, even hydrocyanic-acid gas being practically powerless against them used at a strength that would not kill the plants affected. The remedy which has found most favor is to search for and destroy the beetles, and a good time for this work is during the months of November and December, when the beetles may often be found congregated upon the plants. By persistently following this method the insect has been practically exterminated in many greenhouses which it formerly infested. By killing the beetles the number of larvæ will of course be lessened. Plants showing severe injury should be pulled out and the soil about them searched for the larvæ; or the larvæ may be killed by means of the bisulphide of carbon applied to the soil about the roots of the affected plants. It should be inserted by means of a metal syringe, a few drops here and there about the roots being sufficient to destroy the

insects. Kerosene emulsion applied in a similar manner and in larger quantity will also kill larvæ, and the use of tobacco waste in liberal quantities about the roots of the plants is advisable, as it acts both as an insecticide and a fertilizer.

We may also take advantage of the wingless condition of this beetle by surrounding the trunks of rose bushes and of the different species of ornamental plants attacked by it with cotton bands, such as are in use against canker-worms and similar species. The bands should be applied before the beetles have found their way to the plants or after jarring the beetles from them.

A CALIFORNIA FLOWER BEETLE INJURIOUS TO ROSES.

During the past summer a species of flower beetle, known as *Hoplia callipyge* Lec., and native to California has been observed by Mr. Schwarz to be very destructive to roses at Fresno, Cal., and vicinity. From that gentleman we have also received specimens of the work of the insect, which show that it is capable of quite serious injury to flowers, but is hardly such a pest as the rose-chaffer, *Macrodaetylus subspinosus*, of the East. It is quite probable since injury by this species of *Hoplia* to roses has not been given much attention by entomologists in available early reports and bulletins, that injury was not noticed until recently but is on the increase, and will probably continue to multiply and spread, since most insects which feed upon wild roses, when they acquire a taste for cultivated ones, prefer the latter.

This species was recorded in volume V of *Insect Life* (p. 343) to be doing much damage to the young fruit buds and blossoms of the Muscat grape in vineyards in Fresno County, Cal. The insect was recognized as a yearly visitor, appearing in spring, and up to the time of writing, May 17, 1893, was known only as an enemy of rose leaves, doing much damage to the young buds. The beetles were said to be very numerous, in some vineyards as many as hundreds to a single vine; in one case about three acres were completely stripped of buds. The beetles were also present on rosebushes about dwellings.

A second correspondent in the same county wrote of similar injury to roses and to grapes at about the same time, a fact which has been briefly mentioned on page 386 of volume VII of the same publication.

This *Hoplia* is one of twelve described species, all of similar size, resembling each other more or less closely. They are oblong flattened beetles, with the body more or less completely covered with flat scales.

H. callipyge (figure 25) belongs to a group in which the posterior claws are not cleft, and in which the anterior angles of the thorax are obtuse, and the hairs are long on the thorax, elytra, and pygidium. It is rather dark brown above and incompletely covered with much lighter grayish brown scales on the elytra. The under surface and pygidium

are densely coated with small, pale grayish, brilliantly iridescent scales. The legs are reddish and sparsely covered on the femora with similar scales.

The length is a little less than three-sixteenths of an inch (7-9^{mm}).

The males, as frequently happens in this genus, differ from the females considerably in appearance. They are usually smaller and so much darker as to look like distinct species. The color of the male is quite dark brown, and the scales are less evident than in the female.

This species appears to be restricted to California, and to be most abundant in the southern portion of that State. The list of localities from which we have received this species or reports of its occurrence includes Los Angeles, Selma, Placer County, Fresno, Kern County, Lake Tahoe, and Sacramento.

Some interesting observations upon this species were made by Mr. Schwarz, who communicated a portion of them to the writer. It appears from his statement that roses are most badly injured, from half a dozen to a hundred individuals occurring on a single flower. The insect is rather generally known in California as rose bug, and even as the rose-chafer, being mistaken by some for the Eastern rose-feeding *Macrodactylus*. A singular and unaccountable fact is that the beetles are very strongly attracted to white and other light-colored roses, such as yellow and pink ones, and to light reds, but the dark reds, are, according to observation, entirely exempt from attack. The beetles bore into and through the roses, completely destroying them. The flowers of the Calla lily are always destroyed, the beetles occurring on them by hundreds. It seems that there is something about this plant—whether the petals or the long yellow spadix—that is poisonous to the beetles, and they die and collect with other insects in decaying masses in the deep calyx of these flowers. Whether or not in this condition they furnish nourishment for the plant remains to be ascertained. The flowers of magnolia, olive, and of various native plants, of which there are not many in the grape-growing regions, are also attacked, the list including late-blooming willows, lupines, and *Eschscholtzias*. As a rule, this species of *Hoplia* occurs too late, at least in the neighborhood of Fresno, to do much injury to the flowers of grape, and the same is true of orange. In fact, on the latter plant, it is possible that the beetles are of some benefit in reducing the surplus of blooms and thus improving the fruiting. Figs, it might be mentioned, because they have no flowers are exempt from attack.



FIG. 25.—*Hoplia callipyge*: female—four times natural size (original).

No damage by this species in the larval stage has been observed, and it seems probable that although the insects may attack the roots and rootlets of growing vegetation, that they subsist mainly upon that which is dying or decayed, and, to a certain extent, also upon soil humus, which contains an excess of decomposing vegetable matter. In this respect it is probable that it resembles the habits of our Eastern rose-chaffer, *Macrodactylus subspinosus*, although the habits of this latter are not perfectly known. Mr. Schwarz observed that in spite of the frequent plowing to which the ground is subjected about Fresno, that it has little effect upon the emergence of the beetles, presumably because they pass through their transformations so deeply in the soil that the plow does not reach them. Where the ground is not plowed it may often be found fairly honeycombed where the beetles have made their exit. The beetles have been observed to crawl back into these holes, presumably for oviposition, and this seems to be a natural habit. Unfortunately, the pressure of other work at the time these observations were made prevented Mr. Schwarz from continuing his investigations.

REMEDIES.

Until we learn more of the life history of this species we can only suggest observations of the same line of remedial and preventive treatment prescribed in the case of the rose-chaffer in Circular No. 11, second series, of this office.

THE ROSE CURCULIO.

(*Rhynchites bicolor* Fab.)

May 16, 1900, Mr. Thomas Redmayne, Washington, Nevada County, Cal., wrote of the depredations of this species, specimens of which he sent. He stated that the curculio appears about the middle of May, or as soon as warm weather sets in, and confines its injuries to rose bushes, puncturing the flower buds; and that, even when occurring in small numbers, these beetles are able to destroy an entire crop of flowers in a small garden, as in fact they had done for the last two years on our correspondent's place. With the approach of cool weather, about September, they disappear.

Hand-picking was resorted to, but without avail, for no matter if every beetle seen was destroyed about the same number could be found next day.

It was noticed that the beetles had the habit, in common with many other curculios, of dropping to the ground when disturbed, and they were captured by placing a hand under them very cautiously and catching them as they dropped.

The species was first noticed in that section about five years previous to the date of writing, no one having seen them earlier. The insect was known by the name of the rose curculio.

This curculio has been known for some time to live upon wild roses, and as early as 1889 was stated to feed upon both rose and raspberry (James Cassidy, Bul. 6, Colo. State Agl. College Exp. Station, p. 18).

June 2, 1891, Mr. Arthur Boyle, Santa Fe, N. Mex., sent specimens of this beetle with report that it was proving very injurious to roses in that vicinity, where it had not been known as a pest before. The beetles were stated to be frequently caught with their long snouts buried deep in the rosebuds, and they seemed also to cut the stem or otherwise injure the bud at the thin portion of the stalk below the calyx. The bud afterwards dropped and died (Insect Life, Vol. IV, p. 137). In volume VII of the same publication (p. 211) this species is stated by Prof. T. D. A. Cockerell to be very troublesome at Santa Fe, N. Mex., by eating holes into buds and bud-stalks of roses, as well as the expanded petals.

July 30, 1897, we received specimens from Dr. E. V. Wilcox with the statement that the beetles bore holes into rosebuds and are much complained of at Bozeman and Missoula, Mont.

This species is also stated to be very common and destructive to roses in Minnesota, destroying both flower-buds and flowers and depositing eggs in the fruit in which the young mature (Lugger, 5th Annual Report Entom. of Minn. for 1899, p. 180).

In the report of Mr. Alexander Craw as Quarantine Officer and Entomologist to the State Board of Horticulture of California for 1893-94 (p. 86), mention is made of this species, with the statement that it is frequently found on ripe blackberries and raspberries, puncturing the fruit with its beak and causing it to decay.

The rose curculio is one of the Rhynchophora typical of the family Rhynchitidae, and may readily be known by its red thorax and elytra and black ventral surface, snout, and legs. In eastern specimens the colors are as indicated, but westward, in Colorado, specimens are found in which the greater part of the head is red, including most of the antennae and the legs. The form of the insect is well illustrated at figure 26. The rostrum, or snout, it will be noticed, is very long—nearly a third the length of the entire body, and the antennae are slender, with a well-marked three-jointed club. The length, exclusive of the snout, is a little less than a fourth of an inch (5–6 mm.).

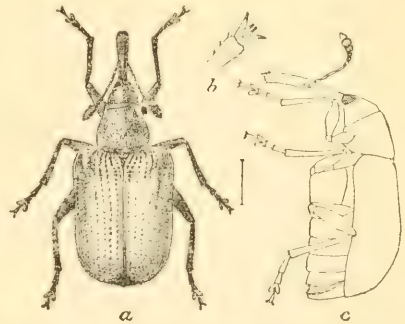


FIG. 26.—*Rhynchites bicolor*: a, female beetle; b, claw; c, female in outline from side; a, c, enlarged; b, more enlarged (original).

This species is well distributed from the Atlantic to the Pacific, and is found more abundantly in the northwest. A list of localities in which it is known, verified in great part by specimens in the National Museum, includes the following: Buffalo, Ithaca, and New York, N. Y.; New Jersey, "common throughout the State" (Smith); Pittsburg and vicinity, Pa.; Washington, D. C.; Tennessee; Missouri; Minnesota; Wisconsin; Iowa City, Iowa; Cheyenne, and National Park, Wyo.; University, N. Dak.; American Fork Canon, and City Canon, Utah; Santa Fe, N. Mex.; Pocatello, Idaho; Montana; eastern Washington; Oregon; San Francisco, San Mateo, San Diego, Los Angeles, Los Gatos, and San Jose, Cal.; Hamilton, Ontario, Can.; Moosejaw, Assa, N. W. T.; Victoria, Vancouver Island, North Bend, and New Westminster, British Columbia.

Hand-picking and jarring the beetles from the infested plants is all that is necessary in ordinary cases of attack. The insect can be destroyed by spraying with Paris green at the rate of about a pound to 150 gallons of water, except when it occurs on plants bearing berries, or on roses soon to be picked.

MISCELLANEOUS INSECTS INJURIOUS TO ROSES.

Roses have been quite subject to insect injury during the last few years, and some of the species which have been particularly destructive or troublesome are worthy of special mention. The rose aphides of the two commoner species have been abundant, and some complaint has been made of the rose-chaffer.

Short notes on some interesting instances of attack follow.

The bristly rose worm (Cladius pectinicornis Fourer.)—Numerous complaints of injury reached this office throughout the month of June and the early portion of July, 1900, from residents of the District of Columbia. In most instances the larvæ were seen and all proved to be this insect. Injury was also noticed by the writer generally throughout the District wherever roses were grown and in neighboring portions of Maryland. In fact the species was more troublesome this year than ever before. Mrs. Flora W. Patterson, Assistant Pathologist of this Department, who furnished larvæ for identification, stated that the roses most affected were La France, General Jacqueminot, a few pink varieties hardy to the District, and some red roses recently imported from Holland.

It was noticed on June 27 that larvæ had attained full growth and were rapidly disappearing from the plants.

A rose beetle, Trichius piger Fab.—An individual of this species which is illustrated by figure 27, was sent to this office June 27, 1900, by Mr. Ernest G. Asmus, a rose grower at West Hoboken, N. J., who reported that it was doing much injury to greenhouse roses, and espe-

cially to the variety known as the Bride. The beetles burrow into the center of the roses, destroy the flowers completely, and also eat the foliage.

Some interesting observations have been made concerning the habit of this ubiquitous flower beetle by Mr. James G. Needham (Amer. Nat., Vol. XXXIV, p. 365). He observed it in the flowers of *Iris versicolor* in New York State. The channeled sepals seeming to offer a favorite place for an afternoon nap, several beetles were found undoubtedly asleep. After repeatedly tickling two of a beetle's feet, it stretched itself like a lazy boy awakening. Although the beetle is not ill adapted by its size for visiting these flowers, it does not seem to pass from flower to flower, and therefore is not an important agent in pollen distribution. Upon reaching an Iris flower it is seemingly habitually deceived as to the point of entrance and endeavors for some time to effect ingress at its center between the branches of the cleft style. After clambering in and out of the central cleft repeatedly the proper entrance is at length stumbled upon. The stupidity of the species is summed up in the statement that if the beetle were seeking pollen it might, had it wit enough, obtain plenty of it by entering the other side up.

The oak pruner (Elaphidion villosum Fab.).—November 8, 1900, we received from Mr. F. A. Marlatt, from Manhattan, Kans., a package of stems of roses, evidently sweet-brier rose (*Rosa rubiginosa*), that had been amputated by this species, some of the larvæ being present in the infested twigs. The oak pruner has been treated somewhat at length in Bulletin No. 18 of the present series (pp. 35–40).

The tobacco bud-worm (Heliothis [Chloridia] rhesiae S. & A.).—August 4, 1900, the writer observed larvæ of this species feeding upon cultivated roses at Marshall Hall, Md. Larvæ entered the earth on the 13th and 14th, and the first moth appeared August 25, twelve days later. This species was described by Smith and Abbot in 1797 (Nat. Hist. Lep. Ins. Georgia, Vol. II, p. 199) under the name of *Phalæna rhesiae*, the specific name having been given it on account of one of its food plants, *Rhesia virginica*. Even at that early date the larva was known to attack tobacco, and was, in fact, called the "tobacco-bud-worm" by the authors mentioned. It was said to attack the bud and blossom, and to be "very pernicious in Virginia and other places, as it destroys the main shoot." Colored figures are given of the moth, larva, and pupa.



FIG. 27.—*Trichas piper*: male beetle, with female foreleg at right enlarged (original).

A short popular account of this insect, with figure, is given on pages 14 and 15 of Farmers' Bulletin No. 120.

THE MORNING-GLORY LEAF-CUTTER.

(*Loxostege obliteralis* Walk.)

Few of our ornamental garden plants suffer so universally from the attacks of insects as does the morning-glory (*Ipomœa purpurea* et al.). The more common forms of injury are shown on the leaves in the shape of numerous more or less rounded holes, the work of various species of tortoise beetles (particular species of *Coptocycla*), and on the edges of the leaves, where little semicircular or semioblong oval pieces are cut out by leaf-cutting bees (*Megachile* spp.). Another form of attack is that which will presently be described, the work of the larva of *Loxostege obliteralis* Walk. (*Phlyctenodes obliteralis* of Hampson's Revision), no account of which appears to have been hitherto published.

During the years 1898 and 1899 Messrs. T. A. Keleher and W. S. Canatsey, of this office, reported injury to cultivated morning-glory in the District of Columbia, and the former gentleman, who devoted considerable time to the gathering of larvæ in different localities, reported injury also to spearmint and plum. The material secured, together with observations which were conducted in previous years by Mr. Theo. Pergande, also of this office, and other information obtained by correspondence with Prof. E. E. Bogue, makes it possible to give a fairly complete account of the insect's life history and habits.

The larva is remarkable not only on account of its great beauty but also from its curious and evidently characteristic habit of gnawing the petioles or leafstalks on the upper side near the leaf in such a manner that only a small portion of the skin and fiber on the under side remains. The leaf hangs downward and gradually wilts and becomes dry, the larva apparently preferring drying leaves as food to fresh ones. The larvæ secrete themselves in the wilting leaves either by drawing together or folding over small leaves, or rolling over the edges of larger ones. In the shelter thus formed they remain during the day, coming forth to feed toward dusk.

When the larvæ appear in any abundance their work is quite apparent, the vines appearing very unsightly where the leaves, partially cut off, die and turn brown. They cut large holes in the leaves, which sometimes present the appearance shown in the illustration at *f*.

DESCRIPTIVE.

The egg.—The egg resembles that of *Phlyctœnia rubigalis*, previously described in this bulletin. It is scale-like, clear, grayish white when first deposited, so nearly translucent and so flat as to show

through it the green of the leaf upon which it is deposited. It is shining, glassy, iridescent, the surface finely granulated and rugose. The outline is tolerably variable—a broad oval, nearly round. The length is about 0.7^{mm} and the width 0.6^{mm} .

The eggs are deposited in rather regular overlapping masses of from three to twenty, a portion of a mass often showing a hexagonal arrangement inclosing one egg. The favorite place of oviposition is on the lower surface of a leaf.

The larva.—The larva when first hatched is clear, grayish white in color, and the markings of maturity show but faintly, being few in number, totally unlike those of the full-grown individual. After feeding, the green of the leaf shows plainly through the outer integument. A half-grown larva is shown in the illustration at *b*.

The moth.—This species is a member of the superfamily Pyralidina, family Pyraustidae, and has recently been placed in the genus *Phlyctanodes* *Guen.* (Hampson, Pr. Zool. Soc. Lond., 1899, p. 208) though still catalogued under *Loxostege* in our latest list (Smith's List Lepid. Boreal Amer., 1894). The earliest description attributed to the species is by Francis Walker (Catalogue Lepidopterous Ins. Coll. Brit. Mus., part XVII, p. 399), who gave it the name *Isopteryx (?) obliteralis*. The type locality is "United States," the date of description, 1859.

The moth is of moderate size and may be recognized by the aid of the accompanying figure (fig. 28, *a*). The general color is described by Grote & Robinson, who gave a detailed characterization of the female under the name of *Botys marculenta* from Pennsylvania (Trans. Amer. Entom. Soc., vol. I, p. 23, 1867), as pale ochre-yellow. It is very pale, corresponding rather closely to, though lighter than, the "cream buff" of Ridgway's Nomenclature. The darker brownish markings are described as obsolete, and though rather faint or suffused in some places the pattern is usually quite constant though moderately variable in distinctness. In the paler individuals the lighter portions of the wings are translucent and more or less strongly iridescent. The lower surface of the wings is more strongly iridescent. In dark individuals, the marginal bands of the wings are sometimes very broad and heavy. The expanse of the fore-wings is about seven-eighths of an inch ($21\text{--}23^{\text{mm}}$). The body of the female is rather stout, and measures with the head about half the wing expanse.

The moth although nocturnal in habit is quite active when the least disturbed, and flies off with a quick darting motion.

The larva.—The larva is of unusual beauty. The general color when full grown is rather pale yellowish green, variegated with deeper green and with numerous very large and more or less rounded and polished somewhat rugose black spots, arranged as shown in the illustration (fig. 28, *b*). The head is a brighter yellow with orange mottling, as is also the cervical shield or anterior portion of the first thoracic

segment, the posterior portion being green. The head and two thoracic segments, with two pairs of legs, are shown at *d*, lateral view. The dorsal surface is darker yellowish and green, the dorsal line being conspicuous dark green. It is bordered each side by yellow, which extends to the rows of black piliferous warts. Each wart is surrounded more or less irregularly with grayish yellow and bears a yellowish brown hair. The second and third thoracic segments are tinged with blue, particularly about the warts. Altogether the coloring, together with the piliferous spots, impart to the larva a somewhat more striped appearance than the illustration shows. The lateral line is wide and very pale yellow. Ventral surface pale green, the legs pale yellow. Surface moderately hairy, the hairs proceeding from the black warts at the anterior portion of the body being light

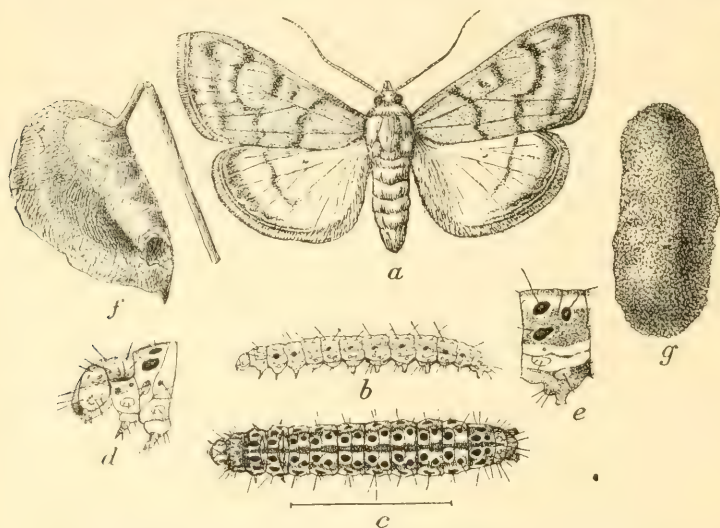


FIG. 28.—*Loxostege obliteralis*: *a*, female moth; *b*, penultimate stage of larva; *c*, last stage of larva; *d*, head and thoracic segments of same from side; *e*, third abdominal segment; *f*, work of larva; *g*, cocoon of hibernating individuals—*a*, $2\frac{1}{2}$ times natural size; *b*, *c*, *g*, 2 times; *d*, *e*, more enlarged; *f*, natural size (original).

brown, those from the posterior portion darker brown. The last segment bears no black spots, but is quite hairy. One of the abdominal segments is shown, lateral view, at *e*. The form is cylindrical and the folds of each segment are pronounced. The length is about six or seven times the width. The figure shows the larva in the somewhat contracted position assumed when at rest. Length when fully mature, 18–20^{mm}; width, 2.7–3^{mm}.

When the larvae are full fed and have been for half a day or more without fresh food the ground color becomes almost uniform light yellow. At this period the striated effect is much diminished, although the black spots become more conspicuous, each one now showing a fine light ring about the insertion of the hairs.

The earlier stages differ in their paler color, the youngest larvæ being nearly white, and in having a much smaller percentage of the piliferous tubercular spots black. Only the lateral row is black, and of these the first thoracic and first abdominal are pale, the hairs being also pale, nearly white. The two pairs of thoracic spots are larger than the others, a character which is more pronounced in the earlier stages than in the antepenultimate. The penultimate stage of the larva is shown from the side at *b*.

The cocoon.—Transformation to pupa takes place in a cocoon, which, with the first generation, is often formed on the surface of the earth, sometimes attached to the dried leaves upon which it has fed. The cocoons of the second generation appear always to be formed normally beneath the earth's surface. The outer surface of the cocoon is covered with sand or earth, giving the appearance represented in the illustration at *g*. Such a cocoon divested of the outer grains of earth, which may be brushed off with a soft camel's hair pencil, measures about half an inch long and a fourth of an inch in diameter. Soon after forming its cocoon the larva becomes contracted to about half or a little less than half its length when fully extended when feeding.

The larvæ during the daytime are unusually sluggish as compared with other Pyralids, such as the grape leaf-folder (*Desmia funeralis*) and are not easily disturbed.

DISTRIBUTION.

The known localities for this species indicate a wide distribution, and it is probable that it is common from Canada to Mexico. The available list of localities includes the following: Washington and Georgetown, D. C.; Cabin John, Md.; Alexandria, Va., and Stillwater, Okla., from all of which specimens have been received. Grote and Robinson's type or types were from Pennsylvania. Lintner records Albany, N. Y., (vicinity); Smith, New Brunswick, N. J., and in the National Museum are specimens from Maine, North Carolina, Kansas, Texas, and Arizona.

DIVISIONAL RECORDS OF ATTACK.

The Divisional records begin with a note made by Mr. Pergande, August 21, 1884, when larvæ were found upon morning-glory in the District. In 1888 Mr. Pergande again observed this species in the District during July and August, feeding on sunflower and dahlia. It was also observed that year by Prof. W. B. Barrows on morning-glory.

Writing under date of July 4, 1896, Professor Bogue stated that he had reared this species (specimens of which were sent) from common morning-glory at Stillwater, Okla. Larvæ were observed to feed at night and to cut the petioles of the leaves upon which they were feeding in the manner previously described.

During August, 1898, Mr. Canatsey reported injury to cultivated morning-glory at Georgetown, D. C., which upon the receipt of specimens proved to be due to this species.

During the second and third weeks of the following June Mr. Keleher brought numbers of the larvæ, which from their peculiar coloration and markings are readily distinguishable, found on spearmint (*Mentha spicata*) growing in this city. Captures were made mostly toward dark, and larvæ were sometimes found at large upon the leaves, but more often in rolled-up leaves. Larvæ were also taken on morning-glory in the same neighborhood, but appeared to prefer mint. Later specimens were found by Mr. Keleher, July 5, feeding on the leaves of a young plum tree, and still later, up to September 28, larvæ were brought by him to this office found on morning-glory in this city and Alexandria, Va. July 8 the writer observed this species at work in a bed of cultivated peppermint (*Mentha piperita*) at Cabin John, Md.; August 21 he found larvæ feeding upon the rough hogweed (*Amaranthus retrofractus*) on the Department grounds; October 2 larvæ were observed on the same plant at Marshall Hall, Md., the leaves of which they cut in the same manner as the more useful plants. Morning-glory growing in the immediate vicinity was not noticed to be attacked.

LIFE HISTORY.

Moths that were placed in confinement, in the same manner as other species that have thus been successfully treated, failed to deposit eggs, and this stage was unfortunately missed.

From the lot of larvæ taken in August, 1884, moths began to issue May 28 of the following year, continuing till June 5.

The 1888 lot gave out moths February 11, 25, and March 9. This lot was evidently kept in an overheated room, which will account for what must be considered the premature appearance of the adults.

The larvæ taken in August, 1898, fed freely upon leaves of morning glory, with which they were confined, becoming full grown toward the end of that month. August 30 one of these formed its cocoon, in which it remained as larva until May 4 of the following year, when it transformed to pupa. The imago issued May 25, other moths continuing to issue until June 3.

The quiescent stage of the larva had thus lasted a little over eight months, and the pupal stage had lasted three weeks.

The remaining larvæ ceased feeding by September 8.

The first moth from the larvæ obtained in 1899, during June, was found to have issued early, June 5, the remainder issuing a few days afterwards. That there is considerable variation in the time of issuance was shown that year by our rearings, moths being present in our rearing jars as late as August 6.

According to Professor Bogue's observations, moths, evidently of

the second generation, emerged from pupæ in about ten days after the larvæ transformed. One of the larvæ captured in 1899 became full fed July 8, entered the earth the following day, and issued as moth July 22. Assuming the pupal stage to have lasted ten days, three days were passed by the larva in inaction.

It is obvious from the above that we have two well-marked generations and there is evidence also of a third generation, of few individuals. Although the earliest appearance of the moths in the field was not noted, it is fairly certain that they begin to issue from the pupæ of the over-wintered larvæ during the latter half of May and continue into June, depositing their eggs at this time for the first new generation, the moths of which appear during the last week of July and the first week of August. From the larvæ of the second generation cocoons were obtained August 14. In other words, larvæ had reached full growth early in the second week of August, and one lot had already entered the earth and spun up by the end of the second week. It has already been shown that larvæ of the second generation pass the winter in their cocoons, form the pupal condition in May, and about ten days after transforming issue as adults. There is evidence that a very small percentage of these, however, issue late in August and lay eggs for a small third generation, the larvæ of which have been observed by Mr. Keleher and the writer at the end of September and during the first week of October.

From the observed food plants it is obvious that we may expect attack in the future on several other plants. The present list includes morning glory, spearmint, peppermint, plum, sunflower, dahlia, and hogweed, plants of different botanical families.

NATURAL ENEMIES.

From the first generation of this insect a number of individuals of a parasitic Dipteron of the family Tachinidæ were reared, all of which evidently came from the cocoons. The species was referred to Mr. Coquillett, who identified it as *Hypostena floridensis* Towns. Flies issued during the last week of July. This species, as its name shows, occurs in the South. Its known distribution extends from the White Mountains of New Hampshire to Jamaica, W. I. It has previously been recorded as a parasite of *Blastobasis nubilella* Zell. and *Schizocera ebena* Nort.

A nymph of the spined soldier-bug (*Podisus spinosus* Dall.) was observed by Mr. Keleher in the act of attacking a full-grown larva of this species the last week of September.

REMEDIES.

The earlier stages of this insect can doubtless be reached by a spray of Paris green or other arsenical, as to a certain extent also the latter

stages, when the larvæ poke their heads forth from their sheltered homes in search of food. The presence of the larvæ as they approach maturity and cut the leaves of their host plants may be readily detected, and at this time hand-picking is all that is necessary.

THE FICKLE MIDGE.

(*Sciara inconstans* Fitch.)

Some insect inhabitants of the greenhouse that have attracted attention in very recent years are the larvæ or maggots of certain species of midges or gnats belonging to the families Cecidomyiidae and Mycetophilidae. The larvæ of three species of the former family attack roses and violets, and one of them has been discussed in former pages of this bulletin on account of its injuries. A large proportion of the Mycetophilidae belong to *Sciara*, a genus of considerable extent, whose larvæ are believed to be for the most part scavengers, feeding upon decaying vegetable matter of different kinds, including fungus growths, whence the name of "fungus gnats" which has been applied to the family. Some of these larvæ live in vegetable mold, under the bark of trees, in putrefying vegetables, in manure, and some attack roots and sprouting seeds in greenhouses, and one of these, *Sciara inconstans* Fitch, the subject of the present paper, has recently been reported by various persons as being quite troublesome.

The subject of injuries by this species is a matter for future investigation, as there is a possibility that it agrees with other *Sciaras* in being a scavenger, and is, perhaps, in some cases attracted to the injured plants observed from the formation of fungus and other growths on them. It is to be regretted that the subject was not investigated earlier.

DESCRIPTIVE.

The adult of this insect is a minute two-winged fly or fungus gnat. Like others of the group to which they belong, these flies are exceedingly delicate, with moderately slender bodies, long slender legs, small heads, and rounded, moderately prominent eyes. The female of this species is shown in the illustration (fig. 29) at *c*. It may readily be distinguished from the male shown at *a* by its larger size, more robust abdomen when gravid, eyes somewhat smaller in proportion to its size, and particularly by the last abdominal segments. A side view of the tip of the abdomen of the female is shown at *f*, the maxillary palpus at *e*, and an enlarged section of the antennæ at *d*. At *b* is shown the peculiar structure of the external organs of the male. The general color of the body and legs is pale brownish yellow, with darker brown thorax, and black head. The wings are still lighter and lightly infus-

cated. The wing expanse is about one-fourth of an inch (5.5–7^{mm}), and the length of the body half that (3–3.5^{mm}).

The eggs are unknown, but they are probably like those of related species, white in color and of oblong shape and exceedingly minute.

The larva, shown at *h*, is a delicate threadlike creature, milk-white in color, with a distinct minute jet-black head. The average length is between 6 and 7^{mm}, the length being about eight or nine times the width, the latter being about 0.8 or 0.9^{mm}.

The pupa shown in the illustration at *g*, ventral view, is free (differing from the pupa of other Diptera in not being incased within its old larval skin). The length is about 3.5^{mm}, which is about three or four times the width. The color is pale yellowish, with darker wing-pads, and still darker head. The antennae and legs are folded down between the wing-pads, as shown in the illustration.

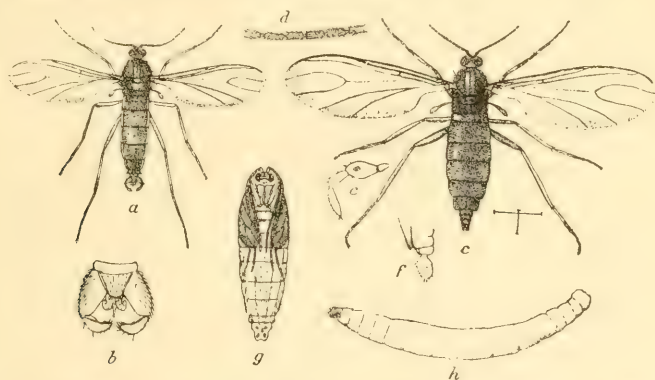


FIG. 29.—*Sciara inconstans*: *a*, male fly from above; *b*, external genital organs of the same; *c*, female; *d*, enlarged antennal joints of same; *e*, maxillary palpus of same; *f*, tip of abdomen of female from side; *g*, pupa ventral view; *h*, larva dorsal view—*a*, *c*, *g*, *h*, much enlarged; *b*, *d*, *e*, *f*, more enlarged (original).

DISTRIBUTION.

Owing to the difficulty of determination of these minute Mycetophilidae, little is known concerning their distribution. Since the description of *Sciara inconstans* at Albany, N. Y., we have learned of a few more localities, a number of which have just been mentioned. The list comprises the following: Ottawa, Canada; Orono, Me.; Jamaica, L. I., N. Y.; Kennett Square, Pa.; Clementon and Riverton, N. J. (Smith); Washington, D. C.; Richmond, Va.; Streator, Ill.; Wooster, Ohio, and Nebraska City, Nebr.

RECENT REPORTED OCCURRENCES.

During the past three years *Sciara inconstans* Fitch has been reported to be more or less troublesome in different portions of the country. Where specific identifications have been made, they are mostly on the authority of Mr. Coquillett, who has also kindly criticized the illustration of the insect here presented.

January 28, 1897. Mr. N. H. Reed, Nebraska City, Nebr., sent specimens, with report that the flies were swarming around his house during the winter, but that he could not ascertain where they came from. He stated that he had never been bothered with these insects before, although he had kept plants in his house for years. No specific injury was reported.

March 1 of the same year, Dr. James Fletcher wrote concerning what was probably this species, stating that the larvæ fed in numbers in the earth of house plants and were suspected of injury to them. The flies were very numerous upon the windows of houses at Ottawa, Canada. A remedy was requested.

January 24, 1898, Mr. F. A. Sirrine, Jamaica, N. Y., sent specimens, with the statement that the larvæ were reported to feed upon roots of roses. He called the adults "black manure gnats."

March 18 of the same year, the late F. L. Harvey, Orono, Me., sent specimens of larvæ and flies of what was identified as probably this species, doing damage to the bulbs of Gloxinia.

December 18, 1899, Mrs. Taylor, Kennett Square, Pa., sent specimens of this insect taken from the soil in potted plants, but with no report as to what plants were injured. The flies had been noticed about a month prior to the date of writing.

February 8, 1900, we received the larva of a species of *Sciara* from Mr. Harry McC. Dowdy, Richmond, Va., with report that this insect was injurious to peas growing in flower pots. These larvæ when received were boring into the cotyledons of the peas. February 14 we received another communication with specimens of the adult, which were identified as *Sciara inconstans* Fitch.

February 27 we received another sending of this insect, with report that the flies were swarming in a greenhouse belonging to Mr. R. D. Kline, a market gardener of Streator, Ill. Injury was feared and remedies requested. Our correspondent stated that no especial damage had been done to any particular plant other than to lettuce, which was affected merely by the presence of the adult insects. The dead bodies of the flies were stated to be abundant in the windows of one of his greenhouses, and for that reason were considered quite undesirable.

Writing March 5, 1900, Mr. Kline stated that he made a practice of "smudging" his six greenhouses, treating two houses one week, and then passing to the next two for the following week. He believes by this method he is enabled to kill off many insects, including the fickle midge, although numbers are left to breed.

Nitrate of soda and pyrethrum, as well as tobacco, were used by Dr. Fletcher upon this or a similar species of *Sciara* in Canada, but without entirely satisfactory results.

THE SAME OR A RELATED SPECIES REPORTED INJURING CUCUMBERS IN
HOUSES.

Numerous complaints have reached this office of injuries to greenhouse plants of various kinds by this or related species of *Sciara*, but as it has been found impossible to obtain specimens of the adult the exact identity of the species remains in doubt. Injury to cucumbers grown under glass was a frequent subject of complaint. One instance of this nature may be cited as an example. November 28 and December 3, 1898, Mr. W. F. Preston, Dixon, Ill., wrote at considerable length, in regard to injuries by an insect which we identified as a species of *Sciara*, and which, he stated, was injuring cucumber vines in forcing houses in that city. There were, he said, at that time four plants for the growing of greenhouse cucumbers for the Chicago market. Stable manure (horse) was considered the best fertilizer, and it was thought both by our correspondent and the writer that the presence of the insect was in part due to this manure. The small gnat-like fly with bluish wings was recognized as the parent of the maggot. As a remedy our correspondent had tried limewater, tobacco water, carbolic acid and water, bisulphide of carbon, sulphur, kerosene emulsion, fir-tree oil, and other substances, with no effect. Brine killed the insects, but also destroyed the vines. The insect was described as having cost the cucumber growers many hundreds of dollars during the year 1898. Messrs. Long & Co. made similar complaints of injuries in the same locality, our correspondence covering the subject extending from 1897 to 1900.

March 26, 1900, Miss Josie K. Carter, Bristol, Tenn., wrote in regard to the larvæ, which, judging from the description, was a species of *Sciara*, that was very troublesome to cucumber vines in that vicinity. The little thread-like worms were described as attacking the vines just under the surface of the earth and peeling the roots, making them look as if hot water had been poured over them.

LITERATURE OF THE FICKLE MIDGE.

The fickle midge was given its English as well as Latin name by Fitch in his second report on the insects of New York (p. 255), the description appearing as *Molobrus inconstans*, and drawn from individuals which had attracted his notice in December from the singular manner in which they ran about upon the paper on which he was writing. Flies were found at this time upon the windows, and it was believed that they had hatched from the earth in some flowerpots which were in the room. The fly was described as advancing two or three inches and then abruptly pausing or moving backward a step or two and instantly running in another direction for the same distance; then it would back up again and start off on another course.

As far as the writer is able to learn from a search through records available at this time, nothing further was gained in regard to the larval habits of the present species until a complaint of injury, by the larva, to the roots and bulbs of Gloxinia plants at South Deer Isle. This report was made by the late F. L. Harvey, in the Report of the Maine Agricultural Experiment Station for 1897 (p. 175). In the report for the following year (p. 127) reference was made to the same species, but the injury was attributed to an unknown species of Thrips. The person complaining of the injury placed slices of potato about the infested plants and the Thrips collected on them in great numbers.

In the September, 1899, number of Entomological News (Vol. X, pp. 201, 202), Mr. Jas. S. Hine published a note on this midge, with illustrations of larva, pupa, and of both sexes of the imago. Concerning injury, Mr. Hine says that the carnations in the greenhouse inspected were dying and that no cause was found except numbers of the minute white larvæ of this species which were boring inside of all the stems that showed serious injury. From all acquired knowledge of the habits of the Mycetophilidæ, Mr. Hine had supposed at first that the plants were killed in some other way and the insects were secondary in the nature of their attack, but by further observation he became convinced that they were feeding upon and injuring the growing plants.

NATURAL ENEMIES.

January 24, 1898, Mr. F. A. Sirrine wrote that the Anthomyiid *Cænosiæ solita* Walk., was preying upon the adult gnats, appearing to feed exclusively upon this insect.

March 2, 1900, Mr. A. B. Eaton called attention to the occurrence of *Cænosiæ solita* in the greenhouses of the Department of Agriculture, and to the fact that they captured other flies in the same locations. One was observed by Mr. Pratt and the writer having an adult of *Dolichopus spectabilis* Loew., a biting fly, in its mouth. They were also stated to be fond of the "white fly" (*Aleyrodes* sp.), and were frequently seen carrying the latter about while still alive. Many adult *Sciara inconstans* were found dead in the greenhouse, and it was thought that they had not only fallen victims to the *Cænosiæ*, but that the presence of the latter in such numbers in the greenhouse had had considerable to do with keeping the gnats in check, as the gnats were comparatively rare, it being difficult to find living specimens at this time.

REMEDIES.

This insect is new as a pest, and we know so little concerning it and its food plants that it is a matter of some difficulty to advise as to the best methods for its treatment. We can, therefore, only suggest remedies that have been used with success against related species. What-

ever is used should be tested first in a small way before trying it on a larger scale. This is particularly true of remedies which might possibly harm the plants affected.

The hydrocyanic acid gas method would, of course, kill all of the adult insects, but would hardly have any effect whatever on the larvæ living and feeding beneath the surface of the ground.

Tobacco in various forms is the standard remedy against similar insects, and, if used in liberal quantities in proper manner, should always produce good results. Some of our correspondents report satisfaction with this remedy against other insects, while others report that it is not entirely efficacious. Refuse tobacco stems kept moist about the plants are sufficiently deadly in their effects on the adults as to keep them in subjection. Some of the juice which soaks into the ground would have the same effect on the larvæ, and tobacco is, moreover, a fertilizer of considerable value.

When practicable, it is always well to sterilize the soil or manure used in the greenhouse by placing it in large closed metal receptacles and subjecting it to about 150 to 200° F. of heat. The same object can be obtained by passing hot steam or hot air through the material used.

Bisulphide of carbon and kerosene emulsion applied to the soil about the roots of affected plants will kill the larvæ, but the former method is rather expensive.

A method of killing the parent flies said to be employed in mushroom cellars in Europe for similar species consists in placing small, lighted lamps in shallow pans filled with water with a little kerosene floating on the surface. This attracts vast numbers of flies, as well as other injurious insects that may happen to be in the greenhouse, all of which are immediately killed when they come into contact with the kerosene. This, though not a perfect remedy, may be of assistance in reducing the numbers of the pest.

Other remedies recently recommended against the related gnats which are the cause of potato scab, namely, solutions of formalin and of corrosive sublimate, should be tested where their use is indicated, as in the case of peas about to be planted. Full directions for this method of treatment and for the preparation of these two insecticides, which, it should be remarked, are fungicides as well, are given in Farmers' Bulletin No. 127 of this Department.

APPENDIX.

Since the present bulletin has been in the printer's hands, the writer has received a copy of Dr. James Fletcher's report as entomologist and botanist of the Experimental Farms of the Dominion of Canada for 1900, in which several of the species here treated are considered.

One of these is the variegated cutworm (*Peridroma saucia* Hbn.), which was the cause of a most remarkable outbreak in Canada, including British Columbia. This matter will be referred to somewhat more at length in a future publication on that species.

A somewhat similar but less formidable outbreak of the spotted cutworm (*Noctua c-nigrum*) was also reported in Canada, and as this latter species has been given more extended attention in the present bulletin it may be well to mention some of the more important features of the outbreak. Injury by this species in Canada was reported from Niagara and in several places north of Lake Ontario. It was also abundant at Ottawa. Almost all kinds of vegetation, with the exception of various grasses, were attacked, the larval habits assumed in this case resembling very closely those of the variegated cutworm. At Whitby the fruit of tomatoes were devoured, the cutworms eating through the skin and consuming the inside. Oats, peas, and cauliflower were also attacked. At Georgiana these cutworms stripped a field of carrots and mangels, devoured the leaves of Canada thistle, gooseberry, chokecherry, and peas, but a field of oats was left untouched.

A parasite of this cutworm (*Euplectrus frontalis* How.), was reared.

The greenhouse leaf-tyer (*Phlyctania rubigalis* Guen.).—A detailed description of the larva of this species and its manner of working is given with reference to injury to roses, violets, and chrysanthemums at Toronto the previous year.

The greenhouse leaf-roller (*Cacæcia parallela* Rob.).—During the year 1900 this species came under notice for the first time in Canada, from its attack upon the foliage of rose bushes in greenhouses at Hamilton, Ontario. Injury was first noticed in June, 1899. A good account, including a full description of the larva, is given.

The cotton cutworm (*Prodenia ornithogalli* Gn.).—A single egg mass from a female *Prodenia eudiotpa* was carefully watched during March, 1901, and it was noted that the eggs hatched on the 30th. At the end of the month the larvæ attained full growth, and all entered the earth May 3. From these the moths began issuing May 28, the pupal period in this instance having lasted twenty-five days. The larger proportion of the larvæ were light in color and a small proportion were quite dark. Specimens of both were isolated, and when the moths issued it was found that the dark larvæ all produced *Prodenia eudiotpa* (the light moth), while the light ones produced *ornithogalli* (dark moth), thus proving dimorphism beyond question. The latter name takes precedence merely because the description appeared on an earlier page.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY.

INSECT ENEMIES OF THE SPRUCE
IN THE NORTHEAST.

A POPULAR ACCOUNT OF RESULTS OF SPECIAL INVESTIGATIONS, WITH
RECOMMENDATIONS FOR PREVENTING LOSSES.

PREPARED UNDER THE DIRECTION OF THE ENTOMOLOGIST

BY

A. D. HOPKINS, PH. D.,

*Vice-Director and Entomologist of the West Virginia Agricultural
Experiment Station.*



WASHINGTON:
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1901.

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DIVISION OF ENTOMOLOGY.

Entomologist: L. O. Howard.

First Assistant Entomologist: C. L. Marlatt.

Assistant Entomologists: Th. Pergande, F. H. Chittenden, Frank Benton.

Investigators: E. A. Schwarz, D. W. Coquillett.

Assistants: R. S. Clifton, Nathan Banks, F. C. Pratt, Aug. Busck, Otto Heide-
mann, A. N. Candell, J. Kotinsky.

Artist: Miss L. Sullivan.

BULLETIN No. 28—NEW SERIES.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY.

INSECT ENEMIES OF THE SPRUCE
IN THE NORTHEAST.

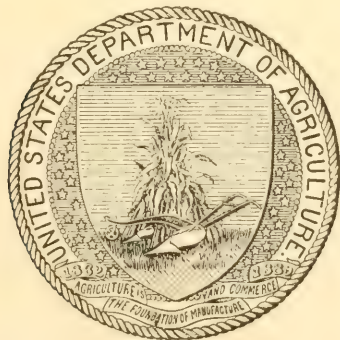
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LETTER OF TRANSMITTAL

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., July 1, 1901.

SIR: I transmit herewith the manuscript of a report by Dr. A. D. Hopkins, entomologist of the West Virginia Agricultural Experiment Station, on a trip taken in the summer of 1900, under the auspices of this Division, to the spruce-growing region in New England, for the purpose of investigating damage done by insects. The attention of the Department was called to a serious trouble affecting the spruce trees, in March, 1900, and Dr. Hopkins was chosen for the investigation for the reason that he has studied forest insects for many years and is generally known as the leading forest entomologist of the country. His report indicates that he was not only able to determine the cause of the difficulty, but to suggest practical measures of relief. I recommend that it be published as Bulletin No. 28, new series, of the Division of Entomology.

Respectfully,

L. O. HOWARD,
Entomologist.

Hon. JAMES WILSON,
Secretary of Agriculture.

PREFACE.

OBJECTS.

The primary objects of the investigations were (1) to determine the cause, or causes, of a prevailing unhealthy condition of the spruce in certain sections of the forests of Maine, New Hampshire, and Vermont, and to study the prevailing influences found to be favorable or unfavorable to the continuance or spread of the trouble; and (2) to determine, if possible, some practical method by which the owners of the timber could prevent or mitigate the great losses of valuable timber from this cause.

It is aimed in this report to give a popular account of the investigations and the principal results, with recommendations of such methods of prevention or control as seem practical.

The details of a technical nature, relating to results of more interest to the entomological student or investigator, will be reserved for a special report on this phase of the subject. It is hoped that this popular discussion will be of interest and value to the student and investigator of economic forestry problems, as well as to the practical forester and lumberman.

ACKNOWLEDGMENTS.

Before proceeding further I wish to express my acknowledgments to all those who have in any way given encouragement and assistance in this work, among whom the following deserve special mention: The executive committee of the regents of the West Virginia University and the director of the experiment station, for the necessary leave of absence; the Berlin Mills Company, through its president, Mr. W. W. Brown, and vice-president, H. J. Brown, for furnishing transportation and guide from Colebrook, N. H., across the State to the steamboat landing on the Magalloway River in Maine, and with guides and other facilities during my stay in the spruce woods of the Androscoggin drainage north of the Rangeley Lakes; to the Parmacheenee Club, through its vice-president, Mr. Henry P. Wells, and manager, Mr. J. A. Dunning, for accommodations at Camp Caribou and use of the Forks, Moosebog, Barkers Lake, and Lower Black camps, together with other favors extended; and finally to Mr. Austin Cary, who, as expert forester to the Berlin Mills Company, rendered most valuable service through his special knowledge of the Maine woods and the conditions in different sections most desirable to visit for investigation.

A. D. HOPKINS.

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INSECT ENEMIES OF THE SPRUCE IN THE NORTHEAST.

OUTLINE OF TRIP.

On May 22, 1900, I arrived at Brunswick, Me., where I learned that Mr. Austin Cary, of that place, had gone with a surveying party to near the head of the Androscoggin River, and that, owing to floods and log jams on the upper streams, some trouble would be experienced in getting through to where he was located. This necessitated a delay of two days, but in the meantime arrangements were made by Mr. H. J. Brown, of the Berlin Mills Company, for transportation and guides from the railroad at Colebrook, N. H., until we found Mr. Cary.

May 24 I left Portland going northwest through New Hampshire via the White Mountain Notch to Colebrook. Here I was met by two guides sent over from Erral with instructions from the Berlin Mills Company, and on May 25 we left Colebrook, going up the Mohawk River valley and through the Dixville Notch near its source, thence down Clear Stream to Erral on the Androscoggin. Here we encountered the floods and log jams which prevented further progress by wagon, and the remaining distance to the Brown farm in Maine was traversed on foot and by canoe.

May 26, after spending a few hours in the woods studying insect enemies of the spruce, larch, and fir, we went on up the Magalloway River about 15 miles to the Camp in the Meadows where we were met by Mr. Cary. The next morning we proceeded farther up the river to the Forks Camp near the mouth of the Little Magalloway. This brought us into the heart of the northwestern Maine woods and within a few miles of one of the localities in which the spruce were dying.

Up to this time the route from Portland through New Hampshire and a small part of Vermont to Colebrook, thence across northern New Hampshire and up the Magalloway in northwestern Maine, led through a region presenting many and varied features of New England forest conditions, and gave a good opportunity to note in a general way some of the influences which contribute to the multiplication of insect enemies of trees, as well as those which contribute to their decrease, or even the extermination of certain species which confine their attack to matured timber. No opportunity was had, however,

to make a detailed study of any of the problems presented or suggested by the prevailing conditions until we reached this place.

May 28 we entered the undisturbed spruce forest in the vicinity of Wight's loggers' camps on Twin Brook, where the conditions were found to be especially favorable for commencing the investigation of a trouble which for forty or fifty years has attracted so much attention and caused the loss of vast quantities of spruce timber in northern New England and in New Brunswick.

After spending two days here in a thorough examination of a large number of infested living, dying, and dead trees, which bore every evidence of having been killed by insects, we extended our investigations further into the forest and across the divide to the Cupsuptic River drainage, and thence across to Lincoln Pond, where extensive summer cutting and peeling of the timber had been carried on. The examination of a great many dying and dead trees, together with a study of the conditions in the cuttings, left little doubt as to the primary cause of the prevailing trouble. Indeed, sufficient evidence was found to enable me to suggest to Mr. Cary a possible remedy, in providing girdled trees to attract the destructive insects, thus concentrating their breeding operations in sections of the forest where, by the ordinary logging operations, the entrapped enemy would be transported to the streams and thus destroyed.

The following day we returned to Wight's Camps, and thence went across to Black Cat Brook, Parmacheenee Lake, and Camp Caribou. Three days were spent in the vicinity of this camp, and on June 4 we proceeded to the Little Magalloway, and up this stream to Hamel's Camp. Thence the next day we went to near its source and the summit of Rump Mountain. This route, leading as it did through an extensive burned-over area, recent cuttings, and undisturbed forest, where much dying and dead timber was found, gave an excellent opportunity for the successful prosecution of the investigations. The observations we were enabled to make from the summit of the mountain were also of especial interest and importance.

We returned to Camp Caribou June 7, where I was joined by Mr. Henry Carter, who had instructions from Mr. Cary to accompany me on an exploration in the heart of the wilderness north of Camp Caribou. We started on June 8, going to Little Boys' Falls on the Magalloway; thence by trail and canoe to and above Moose Bog Camp, and thence by trail via the Game Keeper's Camp to Barkers Lake, which is located near the Canadian line and forms the principal source of the Magalloway. From here we returned by trail to Lower Black Camp and thence to Camp Caribou, where we arrived in the evening of June 11.

This trip enabled me to gather much valuable information relating to the distribution of the trouble; the condition of the timber that had been dead five to twenty years; and the relations of old cuttings,

blow-downs, and other prevailing features which had a direct bearing on the problem under investigation.

Mr. Cary joined me again at Camp Caribou, and June 13 we proceeded by the old Danforth trail to the Cupsuptic River, and thence to the Stonehouse on the lake near its mouth. From here we proceeded up the Kennebago River and devoted several days to the exploration of the great spruce region at the sources of this and Dead River. This also included a climb to the summit of Boil Mountain where, as from Rump Mountain, an excellent view was had of the prevailing conditions as to dead and living timber over a vast extent of forest.

Between Kennebago Lake and Beaver Pond we had a good opportunity to study the conditions in the historic blow-downs of 1871 and 1883, which were followed by great invasions of spruce-destroying insects.

We returned to the Cupsuptic June 17, and next day I returned to Brunswick and Portland. After making some investigations on Peak Island and in the vicinity of Portland, and reporting to the Berlin Mills Company some features of the results of my investigations in sections of the Androscoggin region in which they were specially interested, I returned home, where I arrived June 29.

The specimens of insects and their work collected on this trip numbered something over 1,700, including 44 species from the Red Spruce, six from the White, and nine from the Black.

THE ANDROSCOGGIN REGION AND ITS SPRUCE FORESTS.

The Androscoggin drainage north of the Rangeley Lakes and west of the headwaters of the Dead River of the Kennebec, in which the investigations were conducted, is one of great interest, and since the varied conditions prevailing there have a direct bearing on the problems to be discussed further on in this report, it seems fitting and proper that some space should be devoted to its discussion. In this I can do no better than to quote from the writings of Mr. Cary, than whom there is probably no better authority. Indeed, after having gone over the territory with him I learned to have much confidence in his ability as a practical expert forester and a careful and accurate observer of forest conditions.¹

* * * These townships [Grafton, Andover, North Surplus, Letters D and E, and No. 6] that I have referred to form a barrier separating the upper from the lower course of the Androscoggin. To the south is the lower river, flowing approximately east for 50 miles, catching streams from both sides of its course. To the north of that barrier lies the Rangeley Lakes system, again with its axis east and west and about 30 miles in length. The lakes, therefore, situated as they are close under this mountain barrier, receive only trifling tributaries from the south. Their volume is chiefly maintained from the country to the north, which

¹ Paper by Mr. Austin Cary, in Third Annual Report of the Forest Commissioner of Maine, pp. 127, 128, 1896.

drains into them by three considerable streams—the Magalloway, the Cunsuptic, and the Kennebago. The outlet of the system is at the west where the river forces a way for itself close under the eastern face of the White Mountains. At the east, on the other hand, the upper lakes are closely approached on the high but elevated land by the headwaters of the Dead and Sandy rivers, which run into the Kennebec.

Now, as the Rangeley Lakes, with the exception of Umbagog, are about 1,400 feet above the sea, while the country about is, much of it, considerably higher, this Upper Androscoggin country is more elevated than any other area of equal size within the limits of the State.

Here on the headwaters of the Androscoggin is the chosen home of the spruce. Continuous with the high land of northern New Hampshire, a part of the great White Mountain plateau, this region in its elevation, its uneven topography, and its climate seems to afford that combination of conditions which ministers to the perfect development of the spruce. The timber of the Appalachian Mountains farther south is not known to the writer. It is a fact, however, that no other part of Maine ever had any such spruce stand, and probably no portion of New York or New England as is found from here across northern New Hampshire. Only patches of timber elsewhere stand as thick as does the country here. Much of the timber too is of the finest quality and size. * * *

Returning again to Parkertown, let me present some figures that will be used in a further discussion of the problems arising in connection with the management of the Androscoggin land. First is the detailed statement of the trees standing on a sample acre that, fairly representative of the country in its stand of merchantable spruce timber, was thought to be appropriately such also in respect to the proportion of hard and soft wood in large and small trees. Note particularly the number of large spruce trees as compared with those from 6 to 12 inches in diameter. Their relation is no chance or insignificant matter. Much study has shown it to be characteristic of typical Androscoggin spruce land, while from it are drawn hereafter important practical conclusions:

Trees standing on an acre of uncut land in Township 5, Range 3, Oxford County.

Spruce.					Other species.						
Diameter.	Number.	Height.	Volume.	Estimated scale.	Diameter.	Yellow Birch.	Beech.	Maple.	Fir.	Estimated volume.	Estimated scale.
<i>Inches.</i>		<i>Feet.</i>	<i>Cu. ft.</i>	<i>Ft. B. M.</i>	<i>Inches.</i>					<i>Cu. ft.</i>	<i>Ft. B. M.</i>
Over 18 ¹	14	70-90	1,000	3,500	Over 18.....	11	.....	1	.....	1,000	.....
15-18 ¹	14	70-80	600	2,000	14-18.....	6	.....	4	.....	400	.....
12-14.....	9	60-75	210	840	12-14.....	4	12	6	.....	200	.....
10 and 11 ¹	8	50-65	135	502	10 and 11.....	4	3	8	1	300	.....
8 and 9.....	18	40-50	170	510	8 and 9.....	3	3	13	3	200	.....
6 and 7.....	6	35-45	35	.....	6 and 7.....	3	12	3	1	50	.....
3-6.....	32	40	60	.....	3-6.....	8	10	4	44	130	.....
Under 3.....	90	.....	10	.....	Under 3.....	4	29	1	165	20	.....
Total.....	191	.....	2,220	7,352	Total.....	41	49	40	214	2,360	4,000

¹ One worthless tree in each class.

* * * In the estimated scale put upon the sample acre—about 7,400 feet—5,500, or three-quarters of the whole, was in the shape of trees over 14 inches in diameter 4 feet from the ground. That is a fact to be distinctly marked. Three-quarters of the total spruce in the natural stand of the country is mature—ready in the natural course of things to be cut. This is not merely the lumberman's interest. It is the State's interest. In timber like this, growth is balanced

by decay. Dead trees stand scattered throughout it. Upon this very acre there was one. Several more were dying or imperfect, while doubtless several of the 28 full-grown trees scored are every year decreasing in value. These large, old trees, too, cumber the ground. Producing little themselves they yet, by their shading, keep down the young growth, which could make good use of the room. No one can dispute the lumberman's right or interest in regard to these trees.

* * * The Androscoggin drainage, from the spruce point of view, is the best worthy of study of all the rivers of the State. It is also the one, in my judgment, on which a conservative forest policy is likely to go first into effect.

In a letter to Mr. Cary, Mr. J. A. Pike estimates that the spruce then (December, 1895) standing in the Androscoggin basin, at and above Berlin, Me., was 3,000,000,000 feet. He says:

This estimate is based largely on personal examination and entirely upon personal knowledge of the territory and the character of the growth, and after consulting notes and memoranda extending over a period of more than twenty years.

Mr. Cary again refers to the spruce of Maine in a paper read before the Boston Society of Civil Engineers, May 10, 1899,¹ as follows:

It seems probable, then, that 25,000,000,000 feet, board measure, may approximate the amount of spruce woods standing in the State. The total lumber cut in the State in 1896 was something over 600,000,000 feet. Of this, probably 500,000,000 feet was spruce. About two-fifths of this went to the paper and pulp mills.

Six hundred million feet is equivalent to 30 feet per acre on the gross area of the State. Five hundred million feet may be 50 feet per acre on the area of what we might call spruce-producing land. These figures are within the amounts which such stands as have been made attached to ordinary cut-over land as its yearly growth. Certainly they are small in comparison to what we know that scientific forestry has produced elsewhere.

The general inference to be drawn from these facts is not a discouraging one. Our resources are still great, and we may feel justified in using them freely.

At present the botanists recognize three distinct species of spruce from New England, the Red (*Picea rubens*), the White (*Picea canadensis*), and the Black (*Picea montana*) (Plate I), all of which were noted by the writer and their insect enemies studied.

One of these, the Red Spruce, on account of its size, great value, and prevalence throughout the spruce area, is recognized commercially as "The Spruce," while the others, from an economic standpoint, are of secondary or minor importance.

DEAD AND DYING SPRUCE.

The prevailing condition which attracts especial attention in the upper Androscoggin, is the large amount of dead spruce. It stands in clumps of a few trees to several hundred, and as individuals scattered through the forest, or left in the cuttings. In some places the old-felled trunks and tops make travel through the woods exceedingly difficult.

¹Jour. Assoc. Eng. Soc., Vol. XXIII, No. 2, Aug., 1899, p. 5.

While a large amount of dead spruce was observed throughout the area traversed, that which was then dying, or had died within the past one to four or five years, is limited to well-defined areas of greater or less extent, in different sections, but always involving the best stands and largest timber.

The dead spruce is not confined to any particular condition of soil, exposure, or altitude, but is found under all conditions, from bogs to high, exposed, rocky slopes, or whenever the trees attain a diameter of over 12 inches.

SOME CHARACTERISTICS OF THE DYING AND DEAD SPRUCE.

When the trees commence to die, the first indication in their general appearance is a pale tint of the leaves on the upper branches and tops. These soon fall, even before they lose their green color. When the trees are in this stage of decline, the wind or a slight jar, as with an ax, will cause a shower of the needles to fall, and the ground will be covered with them. After the leaves have fallen, the dead twigs present a reddish appearance, rendering them quite distinct and easily recognized from a distance, when viewed from an elevated point. They gradually assume a light-gray appearance, followed by a darker gray; then, a few years later—the actual time not yet determined—the twigs begin to fall; later the branches, and still later the tops break off. Finally, after many years—ten to twenty or more, depending on the soundness of the base and roots—the decaying trunk will topple over, and contribute to the food supply of the young generation of trees, which have sprung up to utilize the sunlight thus made available.

Trees with diseased roots usually fall before they have lost their small branches, and the wood probably decays far more rapidly than in those with sound roots.

The only way the declining, dying, and recently dead trees can be recognized from the trail, or in going through the woods, when the tops come between the observer and the sky, is by the fine dust in the outer bark and moss near the base, the pitch tubes on the bark from near the base up to 10 or 20 feet, the falling or fallen leaves, or the work of woodpeckers. The removal of the outer bark by the birds in search of insects makes the reddish inner bark conspicuous, even on living trees, when they show no other indication of decline. Indeed, the trees on which the birds have been at work stand out distinct, and can be seen for a long distance in the woods.

CAUSES OF DECAY AND DEATH.

There are two causes of decay and death, one or both of which affected each of the many hundreds of trees examined: (1) The work of an insect in the bark on the middle trunk, causing the death of the

tree; (2) the presence of fungi in the bark and wood. The latter has been investigated by Dr. Herman von Schrenk, for the Division of Vegetable Physiology and Pathology, and his report has appeared in a bulletin of that Division. Therefore, only such reference will be made to these diseased conditions as has a direct or interrelated bearing on the insect problem, and methods of preventing losses from their combined attack.

RELATION OF INSECTS TO THE TROUBLE.

With very few exceptions¹ all of the great number of affected trees examined, which were in all stages, from living to old dead ones, throughout the area covered by the trip, showed evidence of depredation by insects; and in nearly every case quite conclusive evidence was found that one species, a bark-mining beetle, had been or was then associated with the primary cause of these unhealthy conditions and death. This evidence consisted in the healed-over burrows in the living bark of healthy, vigorous trees; in broods of this insect which had developed in the bark of living trees during the summer of 1899, the trees yet living in May and June, 1900; in the hundreds of dying and dead trees, with vast numbers of all stages, from young larvæ to adults, of this insect under the bark, where they bred the previous summer and fall; and finally its characteristic galleries in the bark, or on the surface of the wood of old dead trees which had been dead from ten to twenty years, while the logs, stumps, and tops in cuttings showed little evidence of its attacks.

In addition to this common and primary enemy of the spruce, many other species of bark beetles, flat-headed and round-headed bark and wood borers, occurred in the dying and dead trees, some following closely the first attack by the primary enemy, others coming later, and still others in succession until the last vestige of the bark and wood is converted back to earth.

THE SPRUCE-DESTROYING BEETLE.

The observations of the writer lead him to conclude that of all the insect enemies of the spruce, this beetle must take first place as the most destructive. It is the leader in the attack, while the others,

¹ In all forests, and especially those in undisturbed or natural condition, a certain percentage of trees seem to die naturally. While there is no such thing, perhaps, as a natural death of a tree, there are those which, in their struggle for existence with their many younger and more vigorous competitors, become weakened in their vitality and thus are more susceptible to the attack of their numerous enemies among insects and fungi, and also to the injurious effects of unfavorable climatic conditions, which, combined, cause them to die. Trees perishing in this manner, however, occur as isolated individuals, scattered throughout the forest, and seldom, if ever, in clumps.

found in the bark and wood, are followers, allies, dependents, or natural enemies of one or more of the bark and wood miners.

DESCRIPTION OF THE DESTROYER.¹

This insect belongs to the order Coleoptera, the true beetles, which are most distinguished in a general way by their hard wing covers. It belongs to the family of beetles known as Scolytidæ and to the genus *Dendroctonus*. Up to the present time it has, together with several other distinct but closely allied forms, been recognized by entomologists under the specific name *rufipennis*, a name that was applied by the English entomologist, William Kirby, to a species described by him in 1835 from specimens collected on a journey from New York State to the shores of Hudson Bay. It has been determined, however, by comparison with the original specimens now in the British Museum collections,² that the spruce-destroying beetle is quite distinct, and I have applied to it the name *Dendroctonus piceaperda*, meaning spruce destroyer.

The adult (Pl. II, figs. 1, 2) varies in length from three-sixteenths to five-sixteenths inch (4.7 to 6 mm.), and in width from one-sixteenth to nearly two-sixteenths inch (1.9 to 2.6 mm.). It also varies in color from light yellowish in the younger specimens to dark reddish-brown and, in some mature individuals, nearly black. It will be more readily recognized by the general observer from its common occurrence in the bark of dying and recently dead spruce trees; also by the character of its work, described and illustrated further on.

The egg is a small pearly white object, scarcely to be distinguished, if at all, from those of other bark beetles of the same size.

The larva is, upon hatching from the egg, a minute, white, legless grub (Pl. II, fig. 4), which feeds on the inner bark and increases in size until it has attained a diameter equal to that of the adult and a length somewhat greater. It may be distinguished from any other similar larva as yet found in the Eastern spruce by a dark yellowish-brown space on the upper surface of each of the last two abdominal segments (Pl. II, fig. 4a).

The pupa (Pl. II, fig. 3) is nearly white, of the same size and somewhat the same form as the adult, but without free legs and wings, and is found in oblong cavities in the bark of the trees where the broods develop.

¹ Detailed technical descriptions will appear in a special paper to be published later.

² Specimens of the *Dendroctonus* collected from spruce in Maine, together with specimens of another species from Hudson Bay and Lake Superior regions, were sent to the British Museum and were compared, by Mr. Charles O. Waterhouse, with Kirby's types. He found that the one from Lake Superior agreed with the labeled specimen, the one from Hudson Bay agreed with another, and the specimens from Maine were different from any in the type series.

LIFE HISTORY OF THE BEETLE.

The time of year when the investigation was made was especially favorable for studying the hibernating habits of this insect, and enabled the writer to commence a study of its life history with the later part to the close of its dormant or inactive period.

HOW IT PASSES THE FALL, WINTER, AND SPRING.

The fall, winter, and spring, and part of the first summer month are passed in all stages of the larva, from quite small to full grown, as well as in the adult stage, developed the preceding summer or fall.

So far as could be determined by the writer, the eggs deposited too late in the fall to hatch before cold weather sets in, the pupæ that develop too late to change to the adult, and some of the very young and tender adults, do not survive through the winter.

The adults hibernate in the bark and usually but a short distance from where they were located when they transformed from the pupæ or where the winter found them in their primary galleries. The larvæ are found in their mines, where they ceased feeding in the fall. The very young to nearly matured larvæ are often found in living bark, while the developed broods of the adults are nearly always in bark which has recently died. In some trees many dead adults were found, which, owing to some unfavorable condition, probably within the bark itself, had died or been killed by the winter freezing, while in the greater number of infested trees all stages but the eggs and pupæ, had not been injured in the least; indeed, they seemed to be in as perfect health as when they ceased activity in the fall.

WHEN ACTIVITY COMMENCES IN THE SPRING.

When the first individuals were seen on May 28, near north latitude 45°, and at an altitude of about 2,000 feet, all of the hibernating stages were inactive. This condition continued until about June 4, when warmer weather set in and indications of activity were noted. On June 5, at Hammel's Camp, on the Little Magalloway, the matured larvæ were found to be almost ready to change to the pupæ. The next day, in the same locality, numerous pupæ were observed, which had just transformed from the larval stage. From that day on to June 17 the pupæ were commonly met with and the young larvæ were apparently feeding. Toward the 13th the adults showed evidence of uneasiness, as if preparing to emerge, and the first one of the season was observed excavating an entrance in the living bark of a healthy spruce. I was not positive, however, that it had not commenced this excavation last fall and remained in it over winter. Indeed none were observed flying then or up to the time the last observations were

made just before my leaving that region on June 17. It is therefore possible that some individuals pass the dormant period in the outer bark, where they had commenced to excavate entrances in the fall.

THE SUMMER PERIOD.

In the course of Mr. Cary's observations in connection with the girdling experiments some important information relating to the life history of this beetle was noted by him. According to his notes the beetles commenced to emerge about the middle of June. Galleries had been excavated in some of the girdled trees and eggs were deposited by June 19. The first larvæ were noticed on July 28 to 31. Pupæ were common on September 1, with a few recently developed beetles, and on October 4 many of the beetles had fully matured, but none had emerged. It is therefore probable that the beetles will not emerge and attack other trees before the following summer, although a few early developed beetles may emerge in October and enter the outer bark of living trees.

Mr. Cary's observations furnish quite conclusive evidence that in northwestern Maine there is but one brood in a season, even from the hibernating adults, and that the period of development from the egg to the adult is about seventy to seventy-five days—from the middle of June to the last of August.

SUMMARY OF LIFE HISTORY.

These observations would also indicate that activity ceases in the fall by about the middle of October, when all stages of the insect may occur in the bark of infested trees where they, with the probable exceptions of the eggs and pupæ, remain until the first week in June. Activity then commences, the mature larvæ change to pupæ, and by the middle of June those that pass the winter in the adult stage emerge and commence to excavate galleries and deposit eggs. The adults from the hibernating larvæ of different stages, develop and continue to emerge possibly until the last of August. Therefore the eggs deposited by the late-developing beetles produce larvæ which do not complete their development until July or August of the next year. Thus, the period of development may vary from about seventy days to about twelve months, but all broods from eggs to matured and emerging adults remain in the bark about twelve months, of which they are dormant about seven and one-half and active four and one-half.

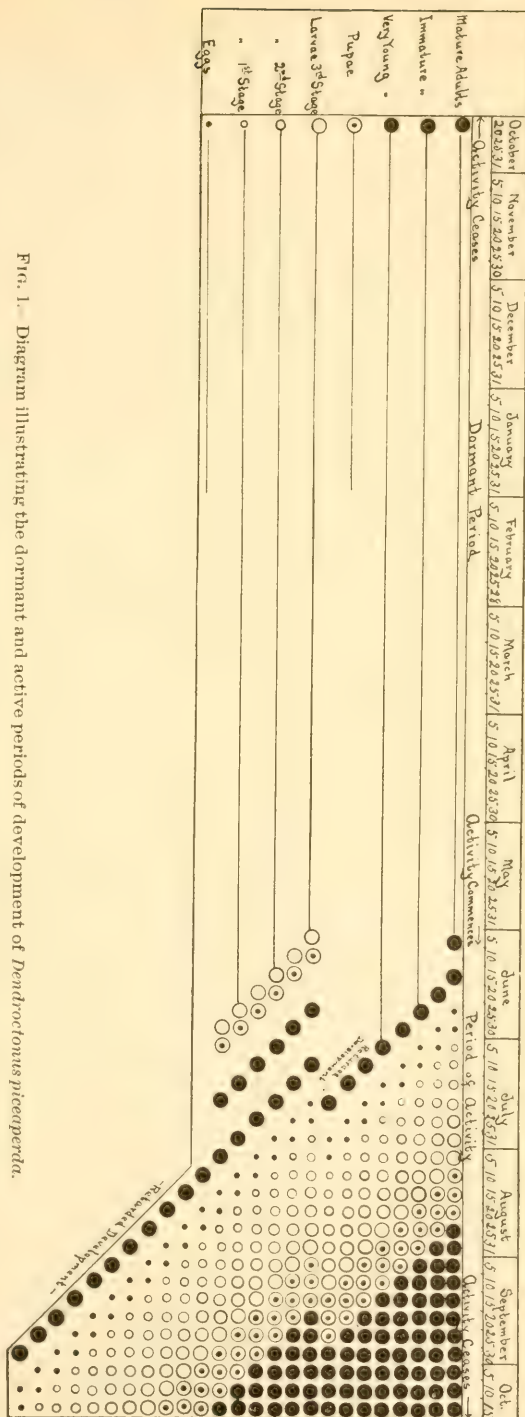
The following diagram will indicate the probable normal rate of development from the different hibernating stages:

EXPLANATION OF DIAGRAM.

The accompanying diagram (fig. 1) illustrates the dormant and active periods and the rate of development of *Dendroctonus piceaperda*. The symbols at the left represent the different stages of the insect in the bark of infested trees when activity ceases, about the middle of October: (●) represents the mature, immature, and very young adults; (⊙) represents the pupæ; (○ ○ ○) represent three stages of the larvæ, and (·) the eggs.

Commencing with the mature adults, in the upper line, the normal, or average, dormant and active periods, and the periods of development are represented as follows: The dormant period of two hundred and thirty-two days ends about the 5th of June; in about ten days more the adults commence to emerge; in twenty days eggs are deposited; in thirty days larvæ commence to appear; in sixty days the larvæ are matured; in sixty-five days pupæ commence to develop; and in eighty days from the time activity commences the first adults develop; they probably continue

FIG. 1. Diagram illustrating the dormant and active periods of development of *Dendroctonus piceaperda*.



to develop until toward the last of September, but they remain in the bark until activity ceases. The hibernating, immatured, and very young adults appear ten to twenty days later than the fully matured ones; they continue to emerge and deposit eggs until about the last of July.

The few pupæ present when activity ceases evidently perish by the last of January, as do also the eggs.

The three stages of hibernating larvæ develop to adults after activity commences in the same ratio as the hibernating adults, but owing to retarded development some of them probably do not attain the adult stage until late in September. Thus adults would be coming out during the entire period of activity, which accounts for the existence of all stages when activity ceases in the fall.

SPECIAL FEATURES OF THE BEETLE'S WORK.

KINDS OF TREES ATTACKED.

So far as known this beetle attacks only the spruce, and the most striking and important feature is its habit of attacking only the larger trees. It is rarely found in trees below 10 inches in diameter breast-high, but in all infested areas is exceedingly common in those over 18 inches at the same height. It also appears to have a decided preference for standing trees, although some evidence was found that it will breed in wind-felled trees and rarely in stumps and logs in cuttings.

HOW AND WHEN THE ATTACK IS MADE.

A study of the living trees which had recovered from a slight attack, as well as those that were infested by different stages of the insect, indicated quite clearly that the first entrances are made in the bark of the healthy tree at a point from 6 to 10 feet from the base, and that trees which are weakened in vitality from disease or other causes may be attacked from near the base to near the first large branches.

The fact that as a rule the infested trees are found in clumps or confined to definite areas of greater or less extent would indicate a social habit, and that the individuals may migrate in swarms from an old to a new locality and settle without any special choice except as to size or number of trees. Thus they invade the trees on all sides, and usually in such numbers as to prevent recovery from the first attack. As soon as the trees commence to decline they are invaded by other bark-mining beetles and grubs, which aid in their final death and decay.

ITS WORK IN AND BENEATH THE BARK.

The entrance and the primary gallery.—This is started, probably by the male, hidden in a crevice or beneath a flake of bark, and, if in a living tree, is gradually and obliquely extended upward or to one side through the inner bark. The male is then joined by a female,

and together they excavate a broad primary or egg gallery (Pl. III) up through the inner bark, often grooving the surface of the wood, for a distance of from 2 to 9 inches. Along the sides of this gallery, which is usually about three times as broad as the beetle, the eggs are placed singly in small cavities or in groups along a notched groove. The eggs are then protected by a mass of borings cemented with gum, which are closely packed, filling up the broad egg gallery, with the exception of a small central burrow which is left or is subsequently excavated through the middle of its entire length. The original entrance is first packed, then an opening to the outside is made in the roof of the gallery a few inches from the entrance, another section is excavated and packed and another hole is made through the roof, and so on until the gallery is completed. After all is finished the adults make one or two irregular lateral branches at the farther end, apparently for an abiding place until they die.

The gum flowing into the wound made by the beetle when it is excavating the entrance is pushed out and a hole kept open through it, thus forming what is known as pitch tubes, which are so conspicuous on the bark of recently attacked trees. After the vitality of a tree is weakened by numerous wounds and an excessive flow of resin, the entrances subsequently made are not marked by pitch tubes; or if a tree is decidedly weakened from other causes before it is attacked, pitch tubes will not be formed.

When numerous beetles are boring into the outer bark the dry dust falls down and lodges in the flakes of bark and the moss on the tree, so that a freshly attacked tree may be identified from its presence.

The secondary or larval mines.—When the eggs hatch, the minute white grubs or larvæ eat their way into the soft inner bark, which by this time has commenced to die and is in the best condition for their food supply. When the eggs are placed in separate cavities each larva makes a separate mine, but when they are massed along the sides, or placed close together, they work side by side and consume all of the inner layer of bark until they have progressed some distance, when they begin to separate and each larva makes an independent mine. (Pl. IV.) While the individual burrow may cross and recross those of its neighbors, it preserves a course of its own and increases in width as its occupant increases in size until the larva attains its full size and ceases to feed. It then excavates a cavity either in the bark next to the wood or next to the outer dry bark, where in due time it changes to the pupa. Here it remains in a semi-dormant condition until the legs, wing covers, and other parts develop. It then sheds its outer skin and becomes an adult winged beetle, soft and yellow at first but gradually hardening and becoming darker. In due time the mature beetle bores its way out to the surface and emerges to fly about in search of a tree in which to excavate galleries for another brood.

THE DISTINCTIVE, VISIBLE EVIDENCES OF THE SPRUCE DESTROYER'S WORK.

The characteristic features which are of considerable importance to the forester and lumberman in recognizing the presence and work of this beetle and its broods may be mentioned, as follows:

PITCH TUBES.

The tubes or balls of pitch, which are pushed out from the wounds made by the beetles when excavating an entrance for their galleries constitute one of the first and most characteristic indications of the presence of this pest in the living spruce. If upon cutting into the bark around one of these pitch tubes, injuries are found like those just described (Pls. III and IV), one may be quite certain that they are the work of the true spruce destroyer.

APPEARANCE OF THE LEAVES.

The leaves of a dying tree infested by this insect change from the dark healthy to a pale or grayish green, and soon fall, thus indicating the presence of this pest. And if the bark of an infested tree is examined at this stage, fully developed larvæ and even fully developed broods of the adult may usually be found.

APPEARANCE OF THE TWIGGS.

After the leaves have fallen the infested trees present, by their reddish appearance, a far more striking contrast with the healthy foliage, and are thus easily recognized at a considerable distance. If the bark is examined at this stage the broods of the spruce destroyer will be found nearly or quite fully developed, or they may have emerged.

APPEARANCE OF THE BARK AND WOOD.

Since it is absolutely necessary for the beetle to deposit its eggs in living or partly living bark, in order for the young larvæ to have the proper conditions for their future development, there is seldom more than one set of broods developed in the same tree, unless, as is sometimes the case, but one side of the tree is attacked one year and the other side the next, when two sets of broods might develop in the same tree. As a rule, all have emerged before the twigs begin to change from their fresh reddish appearance after the leaves have fallen. After this stage is passed the previous presence of the beetle is indicated only by the evidences of its work in and beneath the bark and on the surface of the wood, which may be readily recognized from the illustrations and descriptions given. (Pl. V.) The pitch tubes sometimes remain on the bark several years after the tree dies, and as long as there is any bark on the middle portion of the trunk this

evidence will enable anyone who has given the subject some attention to determine that such trees were attacked while living.

After all of the bark has fallen from the trunk of standing or felled trees, the characteristic grooves in the surface of the wood, made by the beetle when the primary galleries were excavated, are often quite conspicuous, even on trees that have been dead for fifteen to twenty years.

WOODPECKER WORK.

Another, and indeed one of the most conspicuous evidences of the presence of the spruce-destroying beetle, is found in the work of woodpeckers on the middle trunk of the dying and dead trees. Scarcely an infested tree escapes the bird, and the outer bark removed by them in their search for the insect gives such trees at first a red, and later a smooth, light-grayish appearance, which is very conspicuous. Even living trees infested by the insect can be recognized by this means at a greater distance in the woods than by any other of the conditions mentioned. It must be remembered, however, that all spruce trees showing the work of woodpeckers are not necessarily infested by the spruce destroyer. For, as in the case of trees which have been infested with other bark beetles, or the flat-headed and round-headed borers, the birds scale off the bark in the same or a similar manner. Examples, however, of trees dying from the work of these secondary enemies are rarely met with. Therefore the work of the woodpeckers, especially in the Maine woods, is quite reliable evidence of the presence of the spruce destroyer.

A COMMON FUNGUS ON THE BARK OF DEAD TREES.

Nearly all recently dead trees, and even some that are not yet dead but contain broods of the beetle, are found to have a small, yellow, globular fungus (Pl. VI) protruding either from the holes in the roof of the egg galleries or those made when the adults emerged from the bark. This fungus, which grows beneath the bark, pushes its way out to develop spores or fruiting parts.

These fungi are conspicuous objects, and they often occur by hundreds on the bark of the trees for two or three years after they have died and the beetles have emerged. The fact that the work of the spruce-destroying beetle seems to make the conditions more favorable for the introduction and subsequent growth of this fungus indicates that it is more closely associated with the work of this beetle than is any of the other bark and wood-infesting fungi of the spruce. It therefore serves as good external evidence that the dead trees on which it is found were killed by the beetle. It will, however, grow from the burrows made by other insects in the bark, or, as observed in one instance, from the burrows of wood-mining beetles, *Nygloterus birittatus* Kirby, in wood from which the bark had been removed.

THE PRINCIPAL NATURAL ENEMIES OF THE SPRUCE-DESTROYING
BEETLE.

Among a number of insect enemies of the different stages of the beetle at least two are worthy of special mention—one a true parasite, the other a predaceous enemy.

A PARASITIC INSECT.

The commonest parasite of the larvæ is a small four-winged wasp-like insect belonging to the order Hymenoptera, family Braconidæ, genus *Bracon*, and species *simplex* Cress. This insect appears on the wing about the time or a little before the beetles emerge from the bark in the early summer and commences to deposit its eggs by means of a long, stinglike ovipositor which it inserts in and through the bark infested by different stages of the larvæ, on or by which it places its eggs. The minute maggot hatching from this egg attaches itself to the side of its victim and sucks out and feeds upon the liquids of its body. The beetle larva soon dies, and after the parasite larva has attained its full growth as such it incases itself in a thin, paperlike cocoon (Pl. VII) in which it goes through its transformation to the adult. It then emerges and in a like manner continues its good work in destroying the destroyer. While cocoons of this parasite were frequently met with in the larval mines of the beetle in nearly every locality where infested trees were examined, it was nowhere common enough to be of any special service except near the sources of the Kennebagos and Dead rivers. Here it was quite common and had killed a great many larvæ. In one tree as many as six cocoons were found in a piece of bark 2 inches square. It is only in the thinnest bark, however, that this parasite can do much good in destroying the larvæ, and since the beetles usually select only the old trees with thick bark, and do not infest the tops where the bark is thinner, it would appear that this parasite can not, alone, do a great amount of good. In connection with other beneficial factors, however, it contributes its share to reducing the numbers of the destructive beetles, and thus is an important factor.

A PREDACEOUS BEETLE.

Different stages of a beetle closely related to the one that was introduced by the writer into the spruce and pine forests of West Virginia from Germany in 1892-93, to prey upon the destructive pine bark beetles, were frequently met with when examining infested trees, but were not especially common, except in the same section where the parasite was common.

This beetle belongs to the order Coleoptera, family Cleridæ, genus *Thanasimus*, and species *nubilus*. It is antlike in appearance, especially when running about on the bark. The adult is about one-fourth

of an inch long and one-sixteenth broad. Its head is black; middle portion of the body red; the wing covers are marked with zigzag black and gray transverse bands.

The adult emerges from the bark of the infested tree somewhat earlier than the spruce-destroying beetle, and remains hidden under the flakes of bark or in the moss until the adults of the spruce beetle commence to emerge. It then pounces upon the beetles as they emerge and devours them. When those that escape fly away to settle on the living trees, this little clerid enemy evidently does as other clerid species do. It accompanies them and continues its work until the escaping beetles have burrowed into the bark. The adult clerid does not follow them into their galleries, but does the next best thing—deposits its eggs at the entrances, so that the active reddish worms hatching therefrom can find their way into the bark and feed on the bark-beetle larvæ.

When the clerid larvæ attain their full size they retire from the larval mines they have depopulated and enter the central tube in the primary or egg gallery made by the spruce beetle. This, in fact, seems to be a favorite place for them to make their pupa cases in which to transform to the pupa and adult. Some of the larvæ evidently make pupa cases in the outer bark, as is the common habit of nearly all the other species known to the writer; but it would seem that by far the greater number pupate within the central tube in the broad egg galleries excavated by the bark beetle.

This clerid is, without doubt, a very efficient enemy of the bark beetle, especially when it occurs in such numbers as observed in the spruce near the head of the Kennebec River.

A parasite was reared from a pupa case of this clerid which is very closely allied to a parasite of the imported clerid found by the writer in Germany.

BIRDS AS ENEMIES OF THE BEETLE.

As has already been stated, woodpeckers are the most important enemies of the bark beetle, and appear to be of inestimable value to the spruce-timber interests of the Northeast. Indeed, I feel confident that in the many hundreds of infested trees examined at least one-half of the beetles and their young had been destroyed by the birds, and in many cases it was evident that even a greater proportion had perished from this cause alone.

Estimating 100 beetles to the square foot of bark in the average infested tree, and an average of 60 square feet of infested bark, it is possible for each tree to yield an average of 6,000 individuals; one hundred trees, 600,000, and so on. It is therefore plain that, if one-half or two-thirds of this number are destroyed by the birds and other enemies, the amount of timber the remainder can kill will be lessened. This is all the more apparent when it is remembered that it is only

when the beetles occur in great numbers that they can overcome the resistance of the living trees.

The following is a list of the common and scientific names of the woodpeckers of northern New England, kindly prepared for me by Dr. C. Hart Merriam, Chief of the Biological Survey, U. S. Department of Agriculture:

Hairy woodpecker.....	<i>Dryobates villosus.</i>
Downy woodpecker	<i>Dryobates pubescens medianus.</i>
Arctic three-toed woodpecker.....	<i>Picoides arcticus.</i>
Banded three-toed woodpecker.....	<i>Picoides americanus.</i>
Yellow-bellied woodpecker.....	<i>Sphyrapicus varius.</i>
Red-headed woodpecker.....	<i>Melanerpes erythrocephalus.</i>
Flicker.....	<i>Colaptes auratus luteus.</i>
Pileated woodpecker.....	<i>Ceophleus pileatus abietorum.</i>

No positive evidence was obtained as to which one or more of these birds is to be credited with the larger part of the beneficial work, but, from such observations as were made in the woods and information given by Dr. Merriam, and through one of his correspondents, Mr. William Brewster, at Bethel, Me., it would appear that the Arctic three-toed and banded three-toed woodpeckers render by far the greatest service, and probably do their principal feeding during the winter on the species of insect now under consideration.

A FUNGUS DISEASE OF THE BEETLE.

While quite a number of beetles and larvæ were found which had evidently perished from a fungus disease, the percentage dying from this cause was not sufficient to be of any perceptible benefit.

CLIMATIC CONDITIONS.

While very severe freezing, or a sudden change from cold to warm, or vice versa, may kill a great many of the pupæ, young beetles, and even the larvæ, except in a few cases but little evidence was found showing that these conditions had produced appreciable effects.

THE PRINCIPAL INSECT ALLIES OF THE SPRUCE-DESTROYING BEETLE.

Among the large number of different kinds of insects which come to the aid of the spruce-destroying beetle, or follow its attacks, there are at least two which are worthy of especial mention in this connection; one is the spruce Polygraphus,¹ or lesser spruce bark beetle, while the other is the spruce Tetropium.²

THE SPRUCE POLYGRAPHUS.

This is by far the commonest secondary enemy of the spruce throughout the spruce region of West Virginia, and was found to be exceedingly common in all of the sections visited in northwestern

¹ *Polygraphus rufipennis* Kirby.

² *Tetropium cinnamopterum* Kirby.

Maine. It belongs to the same family of beetles as the true destroyer, but to an entirely different genus. The specific name, *rufipennis*, given to it by Kirby, is unfortunately the same as that he gave to the *Dendroctonus* described from the same region. This has caused much confusion in the writings of entomologists and others relating to the insect enemies of the spruce.

This species is enormously abundant in all injured and dying standing trees, and in the bark of the branches, tops, and stumps, in cuttings, windfalls, etc. (Pl. VIII, *e*, and Pl. IX.) Its abundance, together with its habit of infesting the tops of trees immediately after the middle portion of the trunk or base has been attacked by the spruce-destroying beetles, renders it one of the most efficient allies of the primary enemy.

The adult is a small black beetle about .08 of an inch long and .01 of an inch broad. It is easily distinguished from all other spruce bark beetles of similar size and form by the fact that each of its compound eyes is divided by a smooth narrow space. It passes the winter in all stages within the bark of spruce stumps, logs, and the tops of felled and standing trees.¹

THE SPRUCE TETROPIUM.

This is the round-headed bark and wood-miner which was found to be so common in the spruce of West Virginia in 1891, where its work contributed to the rapid decay of the wood of dead trees.² It is very common in the spruce of Maine, where it was observed by the author in the stumps and logs of recently felled trees and toward the base of trees attacked by the spruce destroyer. Indeed, an attack by the latter is followed almost immediately by the Tetrogium adult, which deposits its eggs in the outer bark from toward the middle of the trunk to the base. The young larvæ are capable of mining through the living bark (Pl. X) and continuing their work regardless of the sap and pitch. Therefore, this insect must be classed as one of the principal aids to the spruce beetle in not only causing the death of the trees, but in contributing to the rapid decay of the wood.

OTHER INSECTS.

Numerous other insects which aid in causing the death and decay of spruce might be mentioned (Pls. VIII, XI, and XII), but the two just referred to are by far the most important. There may, however, be an exception in the defoliating insects (Pl. XIII), which, it is believed, may contribute greatly to produce favorable conditions for the attack of the spruce-destroying beetle.

¹ For a more detailed account of this beetle see Bulletin 56, W. Va. Agricultural Experiment Station. "Report on Investigations to Determine the Cause of Unhealthy Conditions of the Spruce and Pine, from 1880 to 1893," pp. 246-251.

² Ibid., pp. 239-242, 259, 438.

HISTORICAL REFERENCES.

In the following paragraphs attention is called to a number of early references to the death of spruce in the forests from New York to New Brunswick, probably caused by the spruce-destroying beetle:

1818.—The earliest reference to dying spruce in the Northeast is probably that contained in a letter from Hon. R. H. Gardner to Mr. A. G. Tenney, editor of the Brunswick, Me., Telegraph, and quoted by Packard.¹ Mr. Gardner stated that "he had often heard his father speak of a great destruction of timber east of the Penobscot in 1818." Dr. Packard also states² that he was informed by Mr. E. A. Coe, who got his information from General Smith, of Norridgewock, that "the spruce growth about that town and Waterville early in this century had been diseased and died very much as in the past few years."

1831-32.—Another early record of dying spruce is that obtained by Mr. Hough from a correspondent, Hon. Daniel W. Taylor, of Sherburne, Vt.³

1840.—About the year 1880 Hough⁴ was informed by a correspondent in Newport, Sullivan County, N. H., "that some forty years ago the mortality of the spruce timber was very great on the hills and mountains in that part of the State * * *."

1844-1859.—When Professor Peck made his investigations of the dying spruce in the Adirondacks, in 1874,⁵ he learned that the spruce had been dying for about fifteen years in Lewis County and that in Rensselaer County the same destruction had been observed about thirty years ago.

1850.—About 1850 the spruce was said to have turned red and died on about 500 acres at Irasburg, Vt., which was supposed to have been caused by worms.⁶

1871-1880.—Between 1871 and 1880 great destruction occurred in the spruce from New York to New Brunswick. Hough in 1882⁷ quoted information from a correspondent in Colton, St. Lawrence County, N. Y., who says of a journey made in August, 1880:

After getting about 40 miles up the river we began to come into a region where a large part of the spruce was dead and at least half of it had lost its value. From such inquiries as could be made we learned that large portions of this timber were destroyed, including the best qualities and trees of the largest size. These injuries had been going on about ten years and were still in progress. The yield of these timber lands was about 6,000 standard of 19-inch logs to the square mile.

¹ Fifth Report U. S. Ent. Com., p. 817.

² Ibid., p. 820.

³ Report on Forestry, 1882, p. 262.

⁴ Ibid., p. 262.

⁵ Proc. Albany Inst., Vol. II, 1876, pp. 294-301; also Twenty-eighth Report New York State Museum, 1878, pp. 32-38.

⁶ Information from J. E. Jamson, Report on Forestry, 1882, pp. 262-263.

⁷ Report on Forestry, 1882, p. 263; see, also, Twenty-eighth and Thirtieth Reports New York State Museum for much additional information by Dr. Peck.

1869-1884.—In 1884 Dr. Packard was informed¹ that in the vicinity of Beed's Hotel, Keene Flats, in the Adirondacks, the spruce had been dying for the past fifteen years.

1874-1881.—In the Home and Farm, of Brunswick, Me., July 14, 1881, Mr. A. G. Tenney states, as quoted by Packard,² that he had been informed by an intelligent and experienced lumberman of North Somerset County, Me., that the first appearance of the insect (that killed the trees) was in 1874, and up to 1881 it was on the increase.

1876-1881.—Hough³ states that great destruction (estimated by Mr. Robert Conners to be 1,000,000,000 feet) of spruce occurred on the Allegash and other tributaries of the St. John River in northern Maine and that these injuries extended through the spruce forests of the whole of Aroostook County and the most northern range of towns in Somerset and Piscataquis counties adjoining.

1875.—Hough⁴ states that about the year 1875 the spruce timber in New Brunswick along the Mivamichi River began to die off in great abundance, the hills suffering more than the valleys, and the dense woods more than those where partial clearings had been made. The largest and best of the timber suffered most, and the young growth appeared somewhat favored, but was not wholly exempt.

1870-1873, 1880-1885.—In 1900, Mr. Cary states, in the Forester, of March, page 52, that—

Old lumbermen tell of a great loss of spruce timber in northern Vermont and New Hampshire, extending into neighboring lands in Canada, which occurred some thirty years ago. The drives of the Connecticut River are said to have been made up for some years thereafter largely of dead timber. The same region suffered again between ten and fifteen years ago.

In Maine beginning about fifteen years ago, a township on the Androscoggin, which at the time was called the best spruce land on the river, had a large part of its value destroyed in the course of three or four years. On the Allegash River, in northern Maine, there are several adjoining townships which, about 1882, were greatly damaged. In some places 90 per cent of the spruce is said to have been killed; in fact, all of the grown timber.

1897.—In August, 1897, Fisk⁵ found the spruce dying and infested with the beetles in northern New Hampshire.

Different authors and their correspondents estimate that 10, 50, and as much 90 per cent of the matured timber had died over large areas.

Different authors and correspondents have estimated that the timber was of little value after the second year, and many claim that it is worthless after the second or third year. Mr. Cary thought⁶ that there was a lessening of something like 50 per cent in available timber within two years.

¹ Fifth Report of U. S. Ent. Com., p. 818.

² Ibid., p. 813.

³ Report on Forestry, 1882, p. 259.

⁴ Ibid., p. 259.

⁵ Bulletin 17, new series, Division of Ent., U. S. Dept. of Agr., pp. 67-69.

⁶ The Forester, March, 1900, p. 53.

Probably the first mention of an attempt to utilize the dying and dead timber was by Professor Peek,¹ which is as follows:

A lumber firm found that their spruce timber was rapidly dying about 1840-1845, and to make their losses as light as possible they made haste to open roads in the forest, that they might draw out and work up as many dead spruce as practicable before decay should render them entirely worthless: but with all of their promptness they suffered no inconsiderable loss, for these dead trees soon became too much decayed to make marketable lumber.

The next mention of attempts to save the dead timber was by Hough,² who referred to a statement in the *National Economist* of Ottawa, Canada, that "one operator in New Brunswick will cut 50,000,000 feet of spruce (in 1881) because of the damage done by insects, and to save it from total loss."

Packard³ was informed by a lumberman that the owners of the dying spruce on the St. Croix were advised in about 1875 to fell and utilize it.

REMEDIES AND METHODS OF PREVENTION.

REVIEW OF PROPOSED METHODS.

In addition to the published references to remedies and methods of preventing loss already quoted, the following should be mentioned in this connection, in order to call attention to the practical and impractical features of some of them:

Professor Peek⁴ suggests the protection of woodpeckers, which, as subsequent observations by Hough, Cary, and the writer show, is a recommendation of considerable importance.

STRIPPING OFF AND BURNING THE BARK.

Peek,⁵ Hough,⁶ and Packard⁷ all recommend cutting the dead trees and stripping off the bark and burning it to destroy the insect; but Peek and Hough expressed some doubt as to its practicability in this country. This old remedy against insect enemies of forest and other trees has been so often recommended in this and other countries that it is becoming stereotyped, but unless it is positively known whether or not the conditions are favorable, necessary, or even possible for its practical application, it should not be recommended or attempted.

As applied to the spruce-destroying beetle, this remedy would seem to be impracticable in the extreme. Indeed it would be in our American forests unsafe under ordinary conditions to attempt to burn the bark in summer on account of the danger of starting forest fires. If, on the other hand, as is the case in the Maine woods, the peeling of the logs is adopted as a business policy in the regular logging opera-

¹Proc. Alb. Inst., 1876, Vol. III, p. 295, and Twenty-eighth Rep., pp. 32-33.

²Report on Forestry, 1882, p. 259.

³Fifth Report, U. S. Ent. Com., p. 819.

⁴Proc. Alb. Inst., Vol. III, p. 299; also 38th Report, p. 36.

⁵28th Report, pp. 36, 37.

⁶Report of 1877.

⁷5th Report, U. S. Ent. Com., p. 822.

tions, then the removal of the bark from infested trees in and accessible to the regular summer cuttings at a time when it is filled with the young stages of the insect is practicable, and may alone, with little additional expense, contribute greatly to the reduction of the pest. In no case, however, would it be necessary to burn the bark, either in summer or winter. The greater number, if not all, of the insects would perish from the drying of the bark in the summer, freezing in winter, and from the attack of birds and other enemies. It is true that some of the adults may escape in the summer to attack other trees, but it is believed that little trouble would result from this source.

DESTRUCTION OF DEAD TREES.

This is another method which is often recommended for the prevention of depredation by insect enemies of forests, meaning in many cases trees which have been dead a long time, as well as stumps and logs in which it is supposed destructive insects breed. As applied to insect enemies of living trees, or those which make the primary attack in living bark, the destruction of old dead trees, stumps, and logs would be worse than useless, since all of the really dangerous enemies emerge from the trees either before they are entirely dead or within one year after they die. The only apparent advantage to be gained as applied to the spruce would be the destruction of a few of the insect depredators on the wood of dead trees, and in this it would be the most exceptional cases where there would be any appreciable benefit.

GIRDLING TREES.

This is an old method practiced in Europe and quite extensively recommended, but, like most other methods, it is only applicable to certain kinds of insects and depends on specially favorable conditions for its desired effect.

INVESTIGATION OF THE GIRDLED-TREE METHOD.

Some evidence found in the felled and diseased standing trees on the first and second days of the investigation, in the vicinity of Wight's camps, suggested to the writer the importance of experiments to determine the relation of girdled trees to the attraction of the insects away from the living; therefore, the girdling of large spruce at different dates during the summer was recommended to Mr. Cary as an important line of work for him to undertake.

HACK-GIRDLED AND PEELED SPRUCE.

This subject was kept in mind throughout the investigation, and some good opportunities were had at different places to study the influence of the common practice of sportsmen, loggers, and surveyors—hack-girdling and peeling spruce to obtain the bark for camp covering.

In the vicinity of Lincoln Pond large numbers of peeled spruce were examined on May 30. The larger number of these had been peeled, as we were informed by the loggers, in July, 1898, and had

evidently died in the summer of 1899. At the time of our examination the bark was found to be infested with great numbers of *Polygraphus*, principally adults, also by round-headed and flat-headed bark and wood-boring larvæ, but no examples of the spruce-destroying *Dendroctonus* were found.

The other trees peeled in June or July, 1899, were, at the time of our examination, living, the leaves green, and the bark above the peeled portion was filled with sap. The bark of these trees was not infested by insects of any kind, so far as we could observe. The peeled trees in both lots ranged from 8 or 9 inches to possibly 18 inches in diameter, but not many of them were over 12 inches.

On June 7 some large spruce were examined near the inlet to Parmecheene Lake which had been girdled and peeled in about 1895. One that had been hack-girdled near the base and again about 6 feet above had been infested with *Dendroctonus*, and the broods had

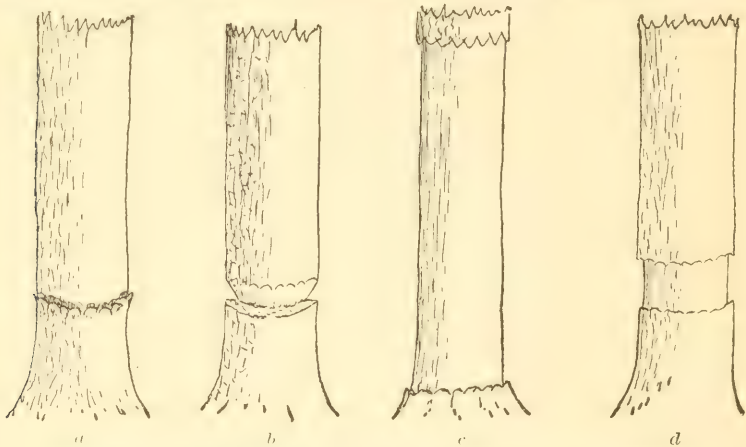


FIG. 2.—Trees girdled by different methods: *a*, Hack-girdled; *b*, girdled to heartwood; *c*, hack-girdled and peeled; *d*, hack and belt-girdled.

developed and emerged. The trees that were peeled, however, were not attacked by *Dendroctonus*, but had been infested by great numbers of round-headed bark and wood borers of the genus *Tetropium*.

On June 8 more hack-girdled and peeled spruce were examined near Rump Pond Camp, which had been infested with *Polygraphus* and other insects, but not with *Dendroctonus*.

REPORT ON GIRDLING EXPERIMENTS BY MR. AUSTIN CARY.

A number of spruce trees were girdled on May 29 and June 13 in the vicinity of Wight's cuttings on Twin Brook; on June 6 near Hamel's Camp, on the Little Magalloway; and on June 16 near Big Island Pond, at the source of the Kennebago River. Upon the writer's return home, written instructions were sent to Mr. Cary regarding the girdling experiments and observations desirable for him to make on the habits and life history of the beetle. The different methods of girdling recommended are indicated in fig. 2. The satisfactory

manner in which these instructions were carried out, the time and labor involved in the work, and the value of Mr. Cary's observations will be indicated by his report.

Mr. Cary commenced these experiments May 29; his report was submitted October 6 and 10, 1900. It is as follows:

CAMP IN THE MEADOWS, MAINE.

October 6, 1900.

DEAR PROFESSOR HOPKINS: I send you herewith report of my observations this season. They do not go very far toward solving the problems suggested, but as to *Dendroctonus* it seems to me they do teach considerable.

Sincerely, yours,

AUSTIN CARY.

All of the trees girdled are of Red Spruce, and unless otherwise mentioned were to all appearances healthy.

The inferences to be drawn from the results depend considerably on surroundings, the lay of the land, and the relation of the girdled trees to infested and healthy ones. I will therefore group my notes according to localities.

GROUP I.

Group I is at edge of Wight's cutting of winter of 1899-1900 and near the clump of infested trees examined on May 28 by yourself and the writer. Unless otherwise stated, the trees were hack-girdled by striking an ax through the bark and into the sapwood around the trunk 3 to 5 feet above the base.

Trees girdled on May 29.

Tree No. 2: Diameter 28 inches; examined June 19, July 9, September 1, and October 4; not attacked by *Dendroctonus*.¹ A few *Xyloterus*² entered the wood in the girdle.

Tree No. 3: Diameter 12 inches; girdled by A. D. H.; examined on June 19, July 9, and September 1; not attacked by *Dendroctonus*. October 4, seemed to be losing leaves: sapwood at girdle and for a foot above stained bluish one-half inch deep.

Trees girdled June 19.

Tree No. 24: Diameter 13 inches. July 10, attacked by a few *Xyloterus*. October 4, no change.

Tree No. 25: Diameter 18 inches. July 10, numerous *Xyloterus* entering at and near girdle. October 4, no change.

These four trees are about 30 yards from infested trees and about 75 yards from the clump of trees first examined on May 28.

Tree No. 26: Diameter 20 inches; 30 yards from clump of infested trees. July 9, a few *Xyloterus* entering wood at girdle; bark infested with *Dendroctonus*, *Polygraphus* especially abundant below the girdle; a few *Sierus annexus* found below girdle. September 1, *Dendroctonus* larvæ were observed. October 4, recently developed beetles and a few *Tetropium* larvæ occurred in the bark, with numerous *Xyloterus* in the wood; the bark was then loose, the leaves down, and the wood turning brown.

Tree No. 27: Diameter, 15 inches; 40 feet from infested trees. July 9, infested by *Dendroctonus* and *Xyloterus* in girdle; *Dendroctonus* galleræ up to 3 inches long, with numerous eggs. September 1, numerous larvæ and pupæ of *Dendroctonus*.

¹ *Dendroctonus piceaperda* Hopk. ² *Polygraphus rufipennis*, Kirby-Hopkins.

² *Xyloterus bivittatus* Kirby.

tonus, also numerous Polygraphus in bark, the sapwood being stained one-half inch deep. On October 4 the bark was dry all around and the leaves falling, Dendroctonus larvæ, pupæ, and recently developed beetles being common above girdle and Polygraphus more numerous below.

Tree No. 28: Diameter, 16 inches: hollow at base and with thin crown; close to infested trees. July 9, not attacked. October 4, two Dendroctonus galleries close to girdle, but no eggs or larvæ; not attacked by Xyloterus even at girdle.

On July 9 a large tree standing by No. 27 was found to be attacked by large numbers of Dendroctonus, and by October 4 was dead and the leaves fallen. Another tree 18 inches in diameter near No. 28 was lightly attacked by Dendroctonus, and by October 4 showed numerous short galleries, but no eggs or larvæ. On October 4 it was noted that a 13-inch spruce, standing between two large infested trees 10 feet apart, had been attacked in 1899, but recovered, and was not again attacked this season. On July 9 numerous trees halfway between No. 26 and the infested trees, as well as one large tree near them, were not attacked. On June 19 I saw no signs of the beetles emerging from the infested trees, and no trees near by were being attacked. I found, however, not far away, in a stump of a tree cut last winter, four Dendroctonus galleries, and more on July 9, with many Xyloterus entering the wood, but could find no other stumps or tops of felled trees which were infested with the Dendroctonus.

GROUP II.

This group is on Wight's "tote" road, higher up the mountain, halfway to Cupsuptic divide, and in the vicinity of numerous infested trees attacked the summer of 1899.

Trees girdled May 29.

Tree No. 4: Diameter, 20 inches: close to infested tree. June 19, infested by Dendroctonus. July 11, abundantly infested, the galleries being as much as 3 inches long and containing eggs: Xyloterus common, entering wood at girdle and elsewhere. September 1, many of the leaves had fallen, and recently developed beetles, pupæ, and large larvæ were found in the bark, with no trace of parasites. October 4, all the leaves fallen: numerous nearly matured adults of Dendroctonus, with few larvæ and pupæ.

Tree No. 5: Diameter, 16 inches; 40 feet to nearest infested tree. June 19, infested by Dendroctonus. July 11, Xyloterus in the wood and Dendroctonus in the bark, but apparently not in great numbers. September 1, Dendroctonus abundant, with pupæ and large larvæ; majority of the leaves fallen. October 4, leaves nearly all down: recently developed beetles some fully matured; also large larvæ and pupæ, with some parasites and one Tetropium larva.

Tree No. 6: Diameter, 15 inches: belt girdled by removing a belt of bark 8 inches wide; located 50 feet away from nearest infested tree. June 19, infested by Dendroctonus. July 11, galleries 3 inches long, with eggs. September 1, majority of leaves fallen: Dendroctonus abundant in bark. October 4, leaves nearly all down; pupæ, matured larvæ, and recently developed beetles of Dendroctonus, with a few parasites: also a smaller bark beetle than Dendroctonus.

Tree No. 7: Diameter, 22 inches; girdled by cutting through the sapwood. June 19 and July 11, not infested. September 1, most of the leaves fallen and the wood is drying without staining: a few, possibly eight, Dendroctonus galleries observed, but very short and without eggs or larvæ: also some Polygraphus and several Tetropium larvæ in bark. October 4, same condition; wood not stained.

Trees girdled September 1.

Tree No. 43: Diameter, 13 inches: a few rods from infested trees. October 4, not infested and in normal condition.

Tree No. 44: Diameter, 13 inches. October 4, in normal condition.

Tree No. 45: Diameter, 13 inches; near infested trees. October 4, in normal condition.

Of the four trees girdled here May 29, three were infested by *Dendroctonus* June 19, this being the first new work of the season observed. Some of the galleries were then 2 inches long. They had numerous eggs, and one ventilation hole was observed started, but not through. The beetles in the galleries in some cases were both black, and in others both bronze, or one bronze and one black.

In order to get further information in this locality, a half acre was laid out by guess, which included all the girdled trees as well as the dead ones and those infested last year. All of the trees were examined and their local relations to the probable source of infestation noted on June 19. The conditions were again studied on October 4, and the results are given below. All trees 10 inches or less in diameter standing on the half acre are omitted.

Condition of trees, over 10 inches in diameter, on one-half acre of land.

Diameter.	Condition June 19.	Condition October 4.
10.	Killed in 1898 or 1899	
18	Killed in 1899; infested with <i>Dendroctonus</i> pupæ, etc.	Sapwood brown and soft; <i>Polyporus</i> fungus on bark.
22	Killed probably in 1898	
25	Killed in 1899, infested with <i>Dendroctonus</i> pupæ, etc.	Sapwood brown and soft.
22	Killed in 1899; infested with pupæ and beetles.	Sapwood brown, streaked and softening. A few <i>Polyporus</i> on bark.
17	Killed probably in 1898	Sapwood on one side rotten; remainder brown and softening; <i>Polyporus</i> on bark.
18	Killed two or three years ago	
16	Attacked last year, but not this; leaves green, but wood and bark drying.	Leaves fallen; wood and bark dry.
20	Hack-girdled; attacked by <i>Dendroctonus</i> . (Tree No. 4, Group II.)	Leaves all fallen; wood and bark drying.
13	Two roots extending into road damaged; attacked by <i>Dendroctonus</i> .	Wood dry; leaves falling.
18	Attacked by <i>Dendroctonus</i> .	Majority of leaves fallen; wood dry and browning.
20	Probably infested last year and again this; bark dead on one side.	All dead; leaves fallen; sapwood browning.
22	Girdled through sapwood; not attacked. (Tree No. 7, Group II.)	Wood drying without stain; 8 <i>Dendroctonus</i> galleries without progeny.
11	Attacked by <i>Dendroctonus</i> last year; not again this; strip of bark and wood on one side dry; top green.	Not attacked; living bark covering scars; leaves still green.
13	Attacked last year; infested with beetles and pupæ; no fresh infestation; part of wood dry; top green; <i>Xyloterus</i> in roots.	Previously dead wood decaying; leaves yellow and majority fallen.
15	Attacked last year, but no work of larvae; not attacked this year.	Not attacked; old scars healing.
15	Belt-girdled; attacked. (Tree No. 6, Group II.)	Dead; leaves nearly all fallen.
16	Hack-girdled; attacked. (Tree No. 5, Group II.)	Majority of leaves down.
12	Hollow at base; small crown; lightly attacked.	Larvæ and pupæ of <i>Dendroctonus</i> abundant.
18	Attacked this year	Dying all around; leaves nearly all fallen; infested by <i>Dendroctonus</i> and <i>Tetropium</i> .
15	Not infested	Not infested.
14	do	Do.
11	do	Do.
12	do	Do.
13	do	Do.
14	do	Do.
15	do	Do.
16	do	Do.
11	do	Do.
18	do	Do.
12	Fine thrifty tree.	Attacked and killed; leaves fallen; strips of wood browning.
20	A heavy-crowned tree	Infested; many <i>Dendroctonus</i> galleries, but no eggs nor larvae; leaves not fallen.
15	Living	Abundantly infested by <i>Dendroctonus</i> , mainly in pupa stage; leaves not fallen.
12	Not attacked	Abundantly infested; bark dry all around; leaves not fallen.
		Not attacked.

Three of the four trees girdled on May 29 were infested by large numbers of *Dendroctonus* on June 19, but there were many other apparently healthy trees which were also attacked. At this date no newly infested trees were noticed that were more than 50 feet away from the source of infection. Later the infestation extended farther, but still it appeared that the trouble spread but slightly beyond the limits of the half acre. Among the trees lightly attacked in 1899 only 1 was reattacked and killed this year. Indeed, it seems that if a tree recovers from the first attack it usually escapes the next year. Numerous examples of this have been observed.

Of the 34 trees noted on the one-half acre, 7 had been dead from one to three years; 4 ungirdled living trees were attacked in June of this year; 4 were not attacked in June, but were infested in October. Of the 4 girdled trees the 2 that were back-girdled and the 1 that was belt-girdled were infested and died, while the 1 that was girdled to the heartwood died without the aid of *Dendroctonus*. Two trees attacked last year recovered and were not attacked this. Two attacked last year died this. Eleven trees were not attacked.

The 9 trees that were dead on June 19 averaged 19.3 inches in diameter. The 8 ungirdled trees that were attacked this year averaged 15.7 inches in diameter. The 3 girdled trees that died averaged 16.7 inches in diameter. The 13 trees that were not attacked averaged 14.2 inches in diameter.

GROUP III.

This group is situated on the "tote" road, near the brook crossing near Wight's Camp.

Trees girdled June 13.

Tree No. 16: Diameter, 17 inches; sound roots, and healthy crown. June 19, two *Dendroctonus* galleries, one at girdle, the other $1\frac{1}{2}$ inches long. July 11, about a dozen *Dendroctonus* galleries, the longest ones 2 inches; without eggs or larvæ; several single beetles dead in short galleries and embedded in the pitch. September 1, six or eight new galleries, without eggs or larvæ.

Tree No. 17: Diameter, 15 inches; back-girdled at base of roots. June 19, not attacked. July 11, one *Dendroctonus* gallery with eggs. September 1, one gallery without larvæ. October 4, no additional attack; tree still living.

Tree No. 18: Diameter, 17 inches; sound roots, and large crown; an infested tree 20 feet away. June 19, lightly infested by *Dendroctonus*; galleries about 1 inch long; had entered at girdle and elsewhere; also some *Xyloterus* in girdle and elsewhere. July 11, thoroughly infested by *Dendroctonus*; galleries 3 inches long; *Polygraphus* (?) also in bark. September 1, thickly infested with *Dendroctonus*, mainly in the pupa stage; *Xyloterus* in wood; sapwood brown and blue; leaves falling. October 4, recently developed adults and numerous *Xyloterus*; leaves half fallen.

A 19-inch tree, the same distance from the infested trees, as well as others 40 feet away, were not attacked.

Tree No. 19: Diameter, 17 inches; sound roots and full top. June 19, not attacked. July 11, abundantly infested by *Dendroctonus*; *Xyloterus* in girdle. October 4, large larvæ, pupæ, and partly and fully developed adults of *Dendroctonus*.

The above trees were all at the time of girdling within a few rods of infested trees.

Tree No. 20: Diameter, 15 inches; standing in group of trees killed last summer; roots sound. July 11, infested with *Dendroctonus*; some galleries $4\frac{1}{2}$ inches long, containing eggs, but none hatched. September 1, abundantly infested with *Dendroctonus*, pupæ, and large larvæ. October 4, large larvæ to light-colored beetles.

July 11, two other trees in same bunch, not girdled, were found to be attacked. I am not certain that they were killed, but think that they were not.

Trees girdled July 11.

Tree No. 35: Diameter, 15 inches; 50 feet from infested trees. September 1, two *Dendroctonus* galleries, but without larvæ; no *Xyloterus*. October 4, same condition.

Tree No. 36: Diameter, 15 inches. September 1, lightly infested by *Dendroctonus*, with small larvæ. October 4, thickly infested; bark drying all around; larvæ half grown.

Tree No. 37: Diameter, 18 inches; 30 yards from infested tree. September 1, thoroughly infested by *Dendroctonus*; half-grown larvæ; leaves beginning to fall. October 4, medium and large larvæ abundant; bark dying; leaves partly fallen.

Tree girdled September 1.

Tree No. 40: Near No. 37. October 4, not attacked.

Aside from the trees mentioned above, girdled and ungirdled, no other trees were attacked in the immediate vicinity of this group; therefore, it would appear that the girdled trees had exerted considerable influence in attracting the beetles.

GROUP IV.

This group of trees is situated on the trail north of Wight's Camp.

Trees girdled July 11.

Tree No. 31: Diameter, 18 inches; away from infested trees. October 4, not attacked by any insect.

Tree No. 32: Diameter, 17 inches; near No. 31. October 4, three *Dendroctonus* galleries about 3 inches long; one at the girdle.

Tree No. 33: Diameter, 20 inches; standing with trees girdled last year; no living beetles found in the bark. September 1 and October 4, not attacked even by *Xyloterus*.

Tree No. 34: Diameter, 17 inches; away from infested trees. September 1 and October 4, not attacked.

Trees girdled September 1.

Tree No. 41: Diameter, 13 inches; standing among dead and infested trees. October 4, no evidence of attack; mold in the girdle.

Tree No. 42: Diameter, 14 inches. October 4, not attacked.

GROUP V.

This group stands near the outlet of Big Island Pond at the head of Kennebago River, where much infested timber was observed on date of girdling.

Trees girdled June 16.

Tree No. 21: Diameter, 16 inches; standing among infested trees. July 28, a few *Xyloterus* entering at girdle, but no *Dendroctonus*. August 11, same condition.

Tree No. 22: Diameter, 16 inches; near infested trees. July 26, one *Dendroctonus* and a smaller species at girdle. August 11, two *Dendroctonus*, with larvæ in bark below girdle.

Tree No. 23: Diameter, 17 inches; with hollow base but externally sound roots; close to infested trees. July 26 and August 11, not attacked.

On July 26 no recent infestations were observed in this locality, although many badly-infested trees were observed here on June 16, in which Professor Hopkins found a far greater number of parasites and predaceous beetles than had been found in any other locality. On August 11 a group of three infested trees was found, which was probably overlooked in July. One of them was infested by

Dendroctonus, Polygraphus, and Xyloterus; another showed numerous Dendroctonus galleries, and the third, a 12-inch tree with decayed roots, had numerous Dendroctonus burrows reaching to the wood, but not completed. Near these trees two others were observed that had each a decayed root, but were not attacked; another 14-inch tree, attacked in 1899, had recovered and was not attacked this year; another one, 20 inches in diameter, with the bark dead on one side half around the trunk, was not attacked. Still another tree, with a long split or fissure in one side, had been attacked last year and died on one side, but the other side was not attacked this year. One of two large living trees standing by the side of one that died last year had two full-length Dendroctonus galleries in the bark, but no larvae. One Tetropium pupa case was observed in the sapwood.

Stumps of trees cut last year within 10 rods showed no evidence of attack by Dendroctonus, although Xyloterus (pupae and immature adults) and small bark beetles were common.

GROUP VI.

This group is at Hamel's Camp, on the line of 5 R. 5 and 5 R. 4, within a mile of the New Hampshire line.

Trees girdled June 6.

Tree No. 8: Diameter, 18 inches; heartwood decaying; external wound; one root decayed; 100 yards from infested tree. October 9, tree broken off; bark dry; leaves all fallen; Polygraphus abundant in bark, but no Dendroctonus.

Tree No. 9: Diameter, 17 inches; thrifty, with sound roots; 50 yards from infested trees. October 9, infested with Dendroctonus, pupae and adults, also Polygraphus and Xyloterus; leaves fallen; wood drying and staining.

Tree No. 10: Diameter, 14 inches; full crown and thrifty; 50 yards from infested trees. October 9, infested with some Dendroctonus; more Polygraphus; also Xyloterus and a few Tetropium; leaves fallen and wood dying.

Tree No. 11: Diameter, 18 inches; close to infested tree; full crown; unsound roots; probably the lower portion of the trunk hollow. October 9, fallen; probably blown over about September 1; not attacked by insects.

Tree No. 12: Diameter, 17 inches; sound roots and full crown; dead and infested trees near by. October 9, infested with Dendroctonus; galleries abundant; adults occur in small numbers; wood attacked by Xyloterus; bark dry and leaves fallen.

Tree No. 13: Diameter, 19 inches; heavy crown and sound roots; 2 rods from infested tree. October 9, infested with numerous Dendroctonus; 1 rood developed to adults; Polygraphus and Tetropium in bark, and Xyloterus in wood.

Tree No. 14: Diameter, 13 inches; standing among others of the same size and larger; all thrifty; 3 rods to infested trees. October 9, infested with Dendroctonus; fully developed broods; also infested with Polygraphus and Xyloterus; leaves fallen; wood dry.

Tree No. 15: Diameter, 16 inches; full crown and sound roots; standing close to infested trees. October 9, infested by fully developed broods of Dendroctonus; wood drying, but the majority of the leaves holding on.

Peeled trees.

About June 20 a considerable number of trees were peeled 5 feet up from base by the loggers here. One was back-girdled for peeling, but was not peeled. This tree was attacked by Dendroctonus, and at this date, October 9, the bark is full of half-grown larvae, but the leaves are green. Among a number of peeled trees standing near girdled trees Nos. 9 and 10 one has a few Dendroctonus at the base; another is infested with Polygraphus in large numbers and the leaves are falling; another one is losing its leaves, but apparently not infested; still others are yet living, but about half of them have a number of Dendroctonus galleries.

A living wind-felled tree here was not attacked. Near No. 11 there are a number of peeled trees, two of which have a few *Dendroctonus* galleries at the base. Several have *Xyloterus* and *Tetropium*, but no evidence of attack has been noticed above the peeled portion. The leaves on all of them are green, but some are beginning to fade. A small log cut near by and left is full of *Polygraphus*, but contains no *Dendroctonus*. No *Dendroctonus* were found here in stumps of last winter's cutting.

Notes accompanying the report.

The first activity of *Dendroctonus* was noted near Wight's on June 19, where a tree girdled on June 13 had galleries in the bark as much as 1½ inches long, with eggs. Trees girdled on May 29 and others had galleries 2 inches long. At other places I failed to note activity of the insects on this date, except four or five burrows in a stump, although I looked for it carefully in infested clumps of trees.

The first larvæ were noticed between July 28 and 31 at Big Island Pond. They had then worked about an inch laterally from the parent galleries.

On July 11 the trees at Wight's which were first infested had galleries as much as 3 inches long, with eggs, but no larvæ. On September 1 the same trees showed the insect mainly in the pupa form; also some large larvæ and recently developed beetles. On October 4 the broods were largely in the full-colored or matured adult form, though some lagged behind, even remaining in the larval form. At this date I could see no signs of any of the beetles emerging, although I looked carefully.

The trees girdled in June and July indicate the time required for the development of the insect. The trees girdled on September 1, I believe, were in no case attacked by insects.

We had a very wet June, and early July was also wet, but the weather was dry in late summer. On September 1 the leaves had not commenced to turn, but by October 1 about half of the leaves of the maples had fallen.

In my identification of the insects I was not always certain about *Tetropium* and *Polygraphus*.

The woodpeckers that work on infested trees are probably American and Arctic three-toed woodpeckers. There may be others. They do little work in the summer.

It seems that any exposure of the wood—as in girdling—attracts *Xyloterus* and possibly *Dendroctonus*.

Trees are frequently met with which are attacked quite abundantly by *Dendroctonus*, which excavate galleries, but no broods develop. Such trees frequently at least—I think generally—escape attack the next year.

My inference as to the attraction exerted by girdled trees is that while many beetles are attracted to them, yet the attraction is not great or from a long distance. The evidence furnished by Group III is affirmative on this point. The results with Group II are inconclusive, mainly from the abundance of the beetles here, but also from exemption of tree No. 7. The results in the case of Group I seem to show that distance is a bar, while those with Group II further indicate that the broods migrate only a short distance. The evidence furnished by trees Nos. 26, 27, and 28 in Group I is affirmative, but the surroundings are such that the test is inconclusive. From Groups IV and V, I can draw no striking or certain conclusions, while Group VI is the most affirmative of all.

As to windfalls, I can only state from general impression that in my opinion they are not specially liable to attack by *Dendroctonus*, and that the same is the case with logs left in yards, tops left in woods, etc.

The fact that 6 of the 9 trees girdled on June 6 were infested and killed, while no others near by were attacked, is strong evidence that the girdled trees attracted the insects.

COMMENTS ON MR. CARY'S WORK.

The experimental work of Mr. Cary and its results are summarized in the following table. The data are arranged in the numerical order of the trees experimented with.

Summary view of Mr. Cary's work.

Number of tree.	In what group.	Diameter of tree.	Date of girdling.	Results to October 4 to 9.
<i>Inches.</i>				
2.....	I	28	May 29	Not attacked; living.
3.....	I	12	do	Not attacked; dying.
*4.....	II	20	do	Attacked; dead; leaves fallen.
*5.....	II	16	do	Do.
*6.....	II	15	do	Do.
*7.....	II	22	do	Not attacked; dead; leaves fallen.
8.....	VI	18	June 6	Not attacked; tree blown down.
*9.....	VI	17	do	Attacked; dead; leaves fallen.
*10.....	VI	14	do	Do.
11.....	VI	18	do	Not attacked; blown down.
*12.....	VI	17	do	Attacked; dead; leaves fallen.
*13.....	VI	19	do	Do.
*14.....	VI	13	do	Do.
*15.....	VI	16	do	Attacked; dying; leaves not all fallen.
*16.....	III	17	June 13	Attacked; living.
*17.....	III	15	do	Do.
*18.....	III	17	do	Attacked; dead; leaves fallen.
*19.....	III	17	do	Attacked.
*20.....	III	15	do	Do.
21.....	V	16	June 16	Not attacked; living.
*22.....	V	16	do	Lightly attacked; living.
*23.....	V	17	do	Not attacked; living.
24.....	I	13	June 19	Do.
25.....	I	18	do	Do.
*26.....	I	20	do	Attacked; dead.
*27.....	I	15	do	Do.
28.....	I	16	do	Not attacked; living.
31.....	IV	18	July 11	Do.
*32.....	IV	17	do	Lightly attacked; living.
33.....	IV	20	do	Not attacked; living.
34.....	IV	17	do	Do.
*35.....	III	15	do	Lightly attacked; living.
*36.....	III	15	do	Attacked; dying.
*37.....	III	18	do	Attacked; dying; leaves partly fallen.
40.....	III	-----	Sept. 1	Not attacked; living.
41.....	IV	13	do	Do.
42.....	IV	14	do	Do.
43.....	II	13	do	Do.
44.....	II	13	do	Do.
45.....	II	13	do	Do.

* Trees exerting decided attraction.

† Trees lightly attacked.

Of the four trees hack-girdled and one tree belt-girdled on May 29, two hack-girdled and the one belt-girdled were attacked. One tree girdled to heartwood was not attacked.

Of the eight trees hack-girdled on June 6, six were attacked and two, having diseased wood and roots, fell without being attacked.

Of the five trees girdled on June 13, all were attacked.

Of the three trees girdled on June 16, two were not attacked and one but lightly.

Of the five trees girdled on June 19, two were attacked and three were not.

Of the seven trees girdled on July 11, two were attacked seriously, two lightly, and three not at all.

Of the six trees girdled on September 1, none were attacked.

Of the fourteen trees girdled on June 6 and 13, all but the two that

fell were attacked by large numbers of *Dendroctonus*, thereby furnishing good evidence that between these dates was the proper period (spring of 1900) to girdle the trees to attract the insects.

Of the twenty-five trees girdled on the other dates—May 29, June 19, July 11, and September 1—only seven were attacked by sufficient numbers to kill the trees.

These results, together with observations by the author during the investigations on the dates of the appearance of the leaves and flowers on different trees, indicate that the best period to girdle spruce trees to attract the spruce-destroying beetle away from other trees may vary with the seasons, but will be about ten days, commencing when the catkins (flower stems) are falling from the birches, and continuing while the fire cherry and the hobble bush are in flower. Another good guide will be to commence when the first pupæ of the destructive beetle commence to appear in the bark and continue until the beetles commence to fly.

SUGGESTIONS AND RECOMMENDATIONS.

The prime objects of the investigation were not only to determine facts relating to the causes of the death of the spruce, but to obtain evidence on which to base suggestions and recommendations for mitigating or controlling the ravages of the spruce-destroying beetle; preventing the total loss of the vast amount of timber already killed, and for reducing or preventing the losses from its ravages in the future.

It has seemed a hopeless undertaking to determine practical methods of combating invasions of destructive insects in a vast wilderness of virgin forest, or to accomplish much toward preventing total loss of the millions of feet of timber killed or injured by them, especially in a country like ours, where improved forestry is in its infancy. But with a knowledge of the principal depredator, its habits, its life history, its enemies, and the conditions, favorable or unfavorable, for its destructive work, facts have been determined on which to base conclusions relating to simple, inexpensive, and practical methods of combating the insects and preventing a large part of the losses.

It then rests with the owner of the property to study the practical features of the problem and the facts determined by the investigator, in order that he may intelligently apply the recommendations to the varying needs and conditions as in each case seems most advisable. It should be remembered that it is the investigator's mission to determine the facts and evidences, and present them with recommendations and suggestions, while the owner of the damaged or threatened property must study and utilize or discard them, as his practical judgment and business interests may indicate is best in each particular case.

METHODS OF REDUCING THE NUMBER OF BEETLES.

The fact that a large number of beetles must attack a living, healthy tree in order to inflict injury sufficient to cause its death, and thus offer the best conditions for its future multiplication and spread, is of special importance since, if their numbers can be reduced below that necessary to kill the trees, their depredations on the living timber must end. The insect can then only survive in weakened, dying, or felled trees. It would thus remain harmless until some specially favorable condition would enable it to accumulate, or migrate from a distance, in sufficient numbers to again successfully invade the living timber.

The facts which have been determined regarding the habits and life history of the beetle suggest three methods by which their numbers can be reduced:

I. To regulate the winter logging operations so that as many of the dying and infested trees as possible can be cut and the logs therefrom placed in rivers, ponds, or lakes between October 1 and June 1.

Different stages of the *Dendroctonus* remain in the bark during the summer, cease active work about the middle of October, remain in the bark over winter and until about the middle of June before the adults emerge. The part of the trees that is infested is that which is utilized for logs. Therefore, if the trees are cut any time after they become thoroughly infested, and the logs are hauled to the landings in the winter, placed in the water and driven out of the woods in the spring, vast numbers of the insects will be either drowned or so far removed from the larger standing spruce that they can do no harm. There are eight months in which to do the work; so if the regular logging operations are (as suggested by Mr. Cary) turned in the direction of the worst infested areas there will be little additional expense in the practical application of this method.

II. To regulate the summer operations so that as many of the infested trees as possible can be cut while the bark will peel, by the removal of which from the logs and stumps of such trees most of the insects will be destroyed.

It is the practice in some sections to cut the spruce at a time when the bark can be readily removed, thus facilitating transportation to the mills; therefore, if the cutting can be turned in the direction of the dying and infested spruce, there will be little or no additional expense in cutting and removing the bark from such trees, and thus all of the eggs and young stages of the beetle will be effectually destroyed by the exposure and the drying of the bark. Another advantage of this method, it would seem, lies in the fact that trees peeled either in the winter or summer can, if necessary, be left in the woods for several years, probably without serious detriment. The preservation of such peeled logs could be facilitated by placing some of the removed bark along the tops of the logs to prevent undue

checking and give some protection from the elements. Such logs could then be taken out when reached in the regular cutting and logging operations.

III. To girdle healthy trees in June to attract the beetles away from timber that it is desired to protect, the girdled trees to be cut and peeled, or placed in the water, in the ordinary practice of logging, previous to the first of the following June.

The use of girdled trap trees has the advantage of not only facilitating the destruction of the insects, but of attracting them away from the matured timber that it is desired to leave standing for future cutting. Still another advantage lies in the fact that trees may usually be selected for this purpose which in the regular logging operations could be cut and hauled to the streams within the limited time required. The beetles which are attracted to the trees in this manner may be disposed of by either of the preceding methods mentioned, so that the only additional expense over the regular logging operations would be the cost of girdling.

The infested spruce which can not be reached by the extension or adjustment of the summer and winter logging operations might be felled and the bark removed from the infested portions of the trunks any time between the first of August and the first of the following June. The young stages of the insects and most of the adults would thus be destroyed by the drying of the bark in summer, or by freezing if removed in the winter.

Another method would be to fell and "score" (by cutting through the bark) the top of the infested portion of the felled trunks or logs to let in the water, which, it is believed, would thus produce an unnatural condition which would kill most of the insects. Experiments are suggested to test the effects of water absorbed by the unpeeled logs whether left in the woods or placed in the water. The adoption of this method is not recommended, however, until experiments prove its value and the conditions are found to be favorable for its practical application.

When the timber is dying rapidly in a given area of greater or less extent, and the trouble is perceptibly spreading, and upon examination it is found that there are comparatively few insect enemies of the beetle, either or all of the three methods should, under favorable conditions for their practical adoption, prove of great service in preventing the undue multiplication of the pest and protecting the living timber from attack.

If the trouble seems to be on the decrease, and upon examination it is found that a large number of natural enemies are operating on different stages of the spruce beetle, it may not be necessary to take active measures for reducing their numbers. Indeed, under specially favorable conditions for the enemies to operate, it may be best to do nothing, for under such conditions an attempt to destroy the enemy

of the spruce would result in destroying the natural enemies of the spruce-beetle also.

This is, however, a problem requiring considerable knowledge of the subject. Indeed, it is difficult even for one having such knowledge to determine whether or not it is best to leave the matter to be taken care of by friendly insects and conditions. Under ordinary conditions it will probably be as well to adopt by way of precaution one or more of the simple methods suggested.

While it may not be best in some cases to cut and remove the infested trees when beneficial insects abound, the reverse is the case when applied to the beneficial woodpeckers.

If, as has been made clear by the abundant evidence found, the birds destroy a large percentage of the spruce-destroying beetles in thousands of infested trees during a single winter, it is plain that if these birds had to confine their work to a half or a quarter as many trees, very few of the insects would escape. For every infested tree taken out of the woods through the adoption of either of the three methods suggested, that many less will remain for the birds to work on and consequently fewer beetles would escape to invade the living trees.

Previous observations by the writer, and a study of the problem of the relation of birds to injurious and beneficial insects, led him to believe that in the end far less service was rendered by the birds than was generally credited to them. This was believed to be the case mainly on account of the failure of the bird to show any decided preference for the injurious over the beneficial insects. In the case of the woodpeckers of the Maine woods, which feed on the spruce-destroying beetle, however, the writer is convinced that, while the birds may, and doubtless do, destroy many insect enemies of the *Dendroctonus*, they do far greater good than harm. It would seem, however, that the relation of the birds to the beneficial insects of the northern spruce forests presents some novel features which either do not exist or have not been noted in other sections of the country.

The adults and larvæ of the common Clerid beetles are among the most efficient insect destroyers of bark beetles. In other sections the larvæ of these friendly insects, as a rule, after they have attained their full growth, go into the outer bark to undergo their transformations and to pass the winter. Here they are in especial danger of destruction by the woodpeckers. It appears, however, that in the northern spruce woods they have learned, possibly through the survival of the fittest, or the perpetuation of an acquired habit, to escape the birds by going into the central tubes or tunnels in the main galleries made by the spruce beetles to construct their pupa cases and undergo their transformations.

It is also probable that the habit of the principal parasite of the spruce beetle, which makes its cocoons in the inner bark, may enable it to escape the birds. The fact, also, that these parasites must have

thin bark through which to insert their ovipositors and reach the *Dendroctonus* larvæ when depositing eggs suggests that this class of beneficial insects may be favored in their work by the removal of the outer thick bark by the bird. Thus the parasite would be able to kill many of the beetle larvæ that escape the birds.

If the spruce-destroying beetle should become rare, through the efforts of the lumbermen and the work of birds and other natural enemies, the lumbermen might repay the birds for their great services by providing food for them. This could easily be done by girdling to the heartwood numbers of spruce trees in June and leaving them stand until the following spring. These would be infested by numerous other bark beetles, like *Polygraphus*, which breed in the cuttings and are readily attracted to injured trees. Flat-headed and round-headed bark-mining grubs would also be attracted to and breed in such trees and would furnish food for the birds. The trees could be cut in the spring following, so that there would be no loss and possibly much gain.

The owners of the spruce of the Northeast owe a lasting debt of gratitude to these friendly birds, and should exert every possible effort to protect them and increase their numbers so that their good work may continue.

UTILIZATION OF DEAD SPRUCE.

While this is an economic problem for the consideration of the expert practical forester, it may not be out of place for the writer to contribute the results of his observations, which, if not authoritative on such a question, may at least be suggestive.

The observations of the writer led him to believe at the time the investigations were being made that a considerable quantity of the dead timber which had been dead five to fifteen years or more (Pl. XIV) had yet considerable value, especially as pulp wood. He was all the more convinced of this after a recent visit to the spruce areas in West Virginia, where it was found that just such dead standing and felled spruce as was observed in Maine was here furnishing a large amount of sound pulp wood. Upon examination of this wood in the yard and in the trees before and after they were felled it was found that some of the trees from which considerable good material was secured had been dead at least twenty years. Nearly all were known to have been dead at least seven years, and this in a section where previous investigations indicated that the wood decays more rapidly than elsewhere.

The advantages of utilizing the wood of dead timber for pulp over that for ordinary lumber is in the fact that it can be cut into short lengths, the good taken and the bad left in the woods. The profitable utilization of such material depends, of course, upon the cost of getting it out of the woods, as well as convenient and moderately cheap

transportation to the factories. In the mountains of West Virginia this problem is solved by broad and narrow gauge railroads, with branch tramroads running through the forest, the latter extending into and following up the cuttings. Therefore the cost of taking out the dead along with the living timber is a small item.

The determination of the relative value of the dead timber and its rate of deterioration under different conditions and in different localities, together with recommendations for the practical utilization of that which is worth saving, is a problem which will doubtless receive its due share of attention from Mr. Cary and other expert foresters in northwestern Maine. Mr. Cary is in an ideal position for the future investigation of such matters. The knowledge recently gained by him from being with Dr. Von Schrenk in his investigation of fungous diseases of trees, and the writer, in the investigation of the insect enemies, will probably render the results of his further investigations all the more valuable.

It is plain that, if as large a percentage of the wood of the dead trees remains sound for as long a period as our observations would indicate, the amount to be saved in its utilization at as early a date as possible would go far toward paying the expenses of extending roads for the purpose far in advance of the regular cutting.

IMPORTANCE OF HARVESTING THE MATURED CROP OF SPRUCE.

Since it has been definitely determined that the spruce-destroying beetle confines its attack to spruce trees over 10 inches in diameter, and that by far the larger percentage killed by it range from 18 to 24 inches, it seems clear that the matured or large timber should be harvested as rapidly as is consistent with good business management. This would not only save the larger living trees from attack, but would facilitate the utilization of such of the dead trees as may yet yield a quantity of merchantable material.

This is a problem, however, like the preceding, which must be considered from the standpoint of the expert forester, and, in its application, made to conserve the best interests of the timber owners. It has, therefore, been the writer's intention to do no more than to call attention to what has been learned of the relation of the spruce-destroying beetle to the virgin spruce areas and matured timber as an important factor to be considered in future management.

Mr. Cary refers to the subject of cutting the spruce in damaged and endangered localities in *The Forester*, March, 1900, page 54, as follows:

There need not be, under present conditions, any comparatively great loss. Extensive lumbering is being carried on throughout the region in which the insect is known to exist. The bodies of uncut timber are nearly all accessible. Cuttings can be turned in the direction of the damaged or endangered localities, and cutting serves not merely to save the dead timber to us, but also, it would

appear, to carry away much of the source of infection. The bunchy way in which the dead timber stands is also in our favor. Evidently the normal flight of the beetle is short, for the dead trees, as a rule, stand in groups: those killed one, two, or three years ago, together with the insect colony working perhaps in green timber close beside them. This trouble, indeed, may also be regarded, in one way, as a benefit to our forests. So far as it may determine a policy of thinning rather than stripping the land, it will exert a favorable action which will never be entirely lost on the reproduction of spruce.

SUMMARY.

The results of the investigation and review of literature relating to the unhealthy condition of the spruce in the Northeast may be summarized as follows:

Extensive dying of spruce from New York to New Brunswick has occurred at various times and periods from about 1818 to 1900.

Within this period spruce to the amount of many billions of feet has died, and much of it has been a total loss.

The cause of the death of a greater part of this spruce has been the depredations of insects.

The primary depredator in the forests investigated is a bark-mining beetle, the spruce-destroying beetle, *Dendroctonus piceaperda*, n. sp.

Vigorous trees, to all appearances in perfect health, are attacked and killed by this beetle.

The largest trees and best stands of timber suffer most from its ravages.

It passes the fall, winter, and spring in all stages from young to matured larvæ, and immature to matured and old adults, in the bark of trees attacked by it in the summer.

Activity commences early in June; the beetles commence to emerge from their winter quarters about the middle of June, and continue to come out probably until about the 1st of September.

In the latitude and altitude of northwestern Maine there is but one brood of the insect each year from the first parent beetles that emerge in June, while those that emerge later in the summer do not develop broods of adults until the next summer.

The broods of the beetle do not remain in a dying or dead tree more than one year after it commences to die. The estimated number of adults which, under favorable conditions, may emerge from an average-sized tree is from five to seven thousand.

It is estimated that an average of three pairs of beetles to the square foot of bark on 10 to 15 feet of the trunk of an average-sized tree are sufficient to kill it, and that 6,000 beetles breeding in one tree may be sufficient to kill from 20 to 25 more trees.

The principal insects that aid the primary enemy in killing the trees after the first attack has been made are (1) a smaller bark beetle (*Polygraphus rufipennis*) and (2) a round-headed bark and wood miner (*Tetropium cinnamopterum*).

There are many other bark-mining beetles and bark and wood-mining grubs which may aid the primary enemy in killing the trees and in the subsequent destruction of the wood.

The principal enemy of the spruce-destroying beetle and other bark-infesting enemies of the spruce consists of the woodpeckers, which destroy, it is believed, from 50 to 75 per cent of the broods of the spruce beetle in many hundreds of trees each year.

Two other enemies of the beetle are of special service in reducing their numbers, a small wasp-like parasitic insect (*Bracon simplex*) and an ant-like predaceous beetle (*Thanasimus nubilus* Kl.?).

The principal methods recommended in this report for preventing losses from the ravages of the beetle may be briefly summarized as follows:

I. Regulating the winter cutting so as to include as many of the infested, dying, and dead trees as possible, and placing the logs from the same in the water before the 1st of June.

II. Regulating the summer cutting so that as many recently attacked trees as possible may be cut and the bark removed from their trunks and stumps.

III. Girdling, early in June, a large number of trees, where logging operations will, or can, be carried on the following summer and winter. In the vicinity of infested localities, the girdled trees to be felled and the logs containing the broods of the insect attracted to them either peeled or placed in the water before the first of the succeeding June.

The results of one season's experiment in girdling trees indicate that the best time to girdle spruce for this purpose is when the flowers (catkins) are falling from the birch, and while the fire or bird cherry and the hobble bush are in bloom. The girdled trees should be sound and healthy, and not less than 15 inches in diameter.

The best method of girdling seems to be that of hacking through the bark with an ax into the sapwood and around the trunk 2 or 3 feet above the base.

Suggestions for utilizing the dead and matured living spruce to prevent loss are as follows:

A large percentage of the dead spruce appears to remain sound and valuable for pulp wood for a longer period than has heretofore been recognized.

The matured living timber should be cut and utilized as rapidly as possible to prevent insect attack.

EXPLANATION OF PLATES.

PLATE I.

The spruces of Maine.

a, Red Spruce, dead and living trees at gamekeeper's camp.

b, White Spruce, near Wight's camp.

c, Black Spruce, on trail to Lower Black Pond.

d, In dense spruce woods.



THE SPRUCES OF MAINE.

PLATE II.

Dendroctonus piceaperda Hopk. n. sp.

1. Adult, dorsal view.
2. Adult, lateral view: *a*, Prothorax, anterior view; *b*, tip of elytron, showing arrangements of striae, and interspaces; ♀, last abdominal segment of female, dorsal view; ♂, last abdominal segment of male.
3. Pupa: *a*, Profile of head and prothorax.
4. Larva: *a*, Dorsal plates on last abdominal segment; *b*, foot scars (?) on ventral surface of thoracic segments; *c*, profile of ventral thoracic lobe showing foot scar (?).

PLATE III.

*Galleries and mines of the spruce-destroying beetle (Dendroctonus piceaperda
Hopk. n. sp.)*

Primary and secondary galleries or mines of the spruce-destroying beetle, showing parts of six primary galleries—reduced about one-fourth.

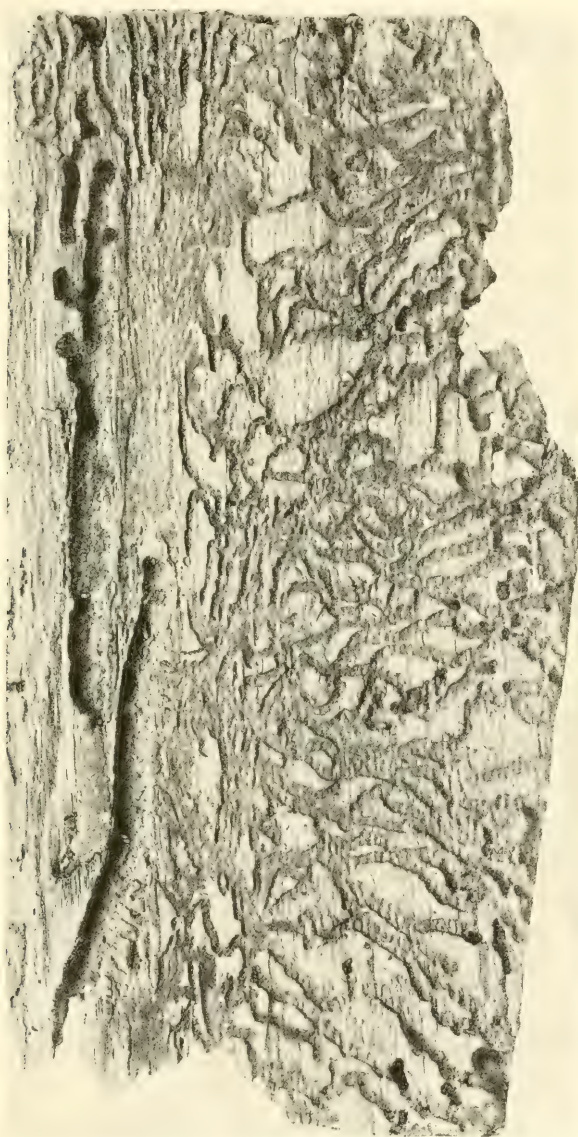


GALLERIES AND MINES OF THE SPRUCE-DESTROYING BEETLE.
(*DENDROCTONUS PICEAPERDA*, HOPK.).

PLATE IV.

Galleries and mines of Dendroctonus piceaperda in spruce.

Primary and secondary galleries or mines of the spruce-destroying beetle.

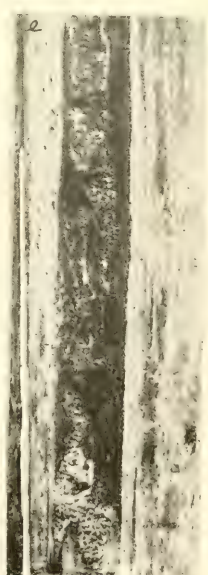
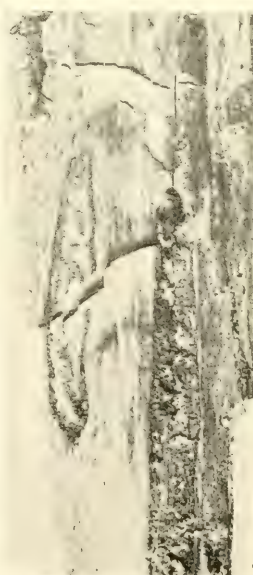
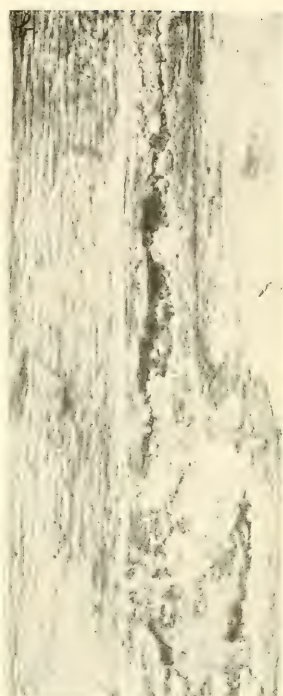


GALLERIES AND MINES OF *DENDROCTONUS PICEAPERDA* IN SPRUCE.

PLATE V.

Old galleries of Dendroctonus piceaperda in spruce.

- a*, Grooves on the surface of the wood of a tree that had been dead about twelve years.
- b*, Wounds, or incomplete galleries, in bark of living tree; wound filled with pitch.
- c*, From dead tree.
- d*, From living tree, in which some of the wounds were healing.
- e*, From old dead tree, the sap wood of which was decaying.



OLD GALLERIES OF *DENDROCTONUS PICEAPERDA* IN SPRUCE.

PLATE VI.

Spruce bark showing growth of fungus, Polyporus volvatius.

A fungus, *Polyporus volvatius* Peck, growing from holes made in the bark of trees killed by the spruce beetle—natural size.

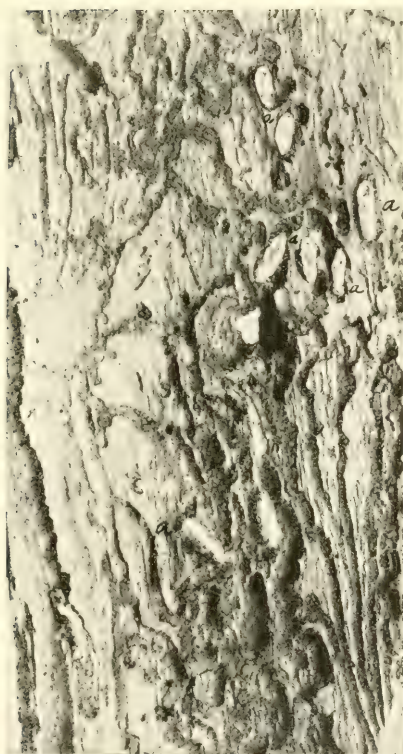


SPRUCE BARK SHOWING GROWTH OF FUNGUS, POLYPORUS VOLVATUS

PLATE VII.

Cocoons of Bracon simplex, a parasite of the Spruce-destroying beetle.

The cocoons of *Bracon simplex*, in the larval mines of *Dendroctonus piceaperda* are shown at *a*.

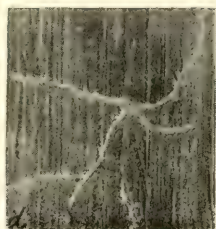
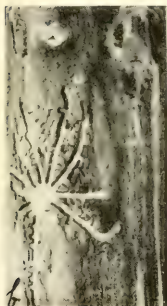
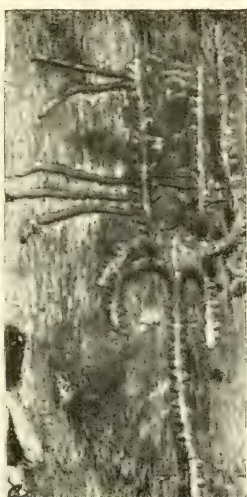


COCOONS OF *BRACON SIMPLEX*, A PARASITE OF THE SPRUCE-DESTROYING BEETLE.

PLATE VIII.

Work of secondary and other enemies of the spruce.

- a.* Work of *Tomicus picea* Hopk. MS. in white spruce bark.
- b.* Work of *Pityophthorus cariniceps* Lec. in spruce bark and grooving the outer wood.
- c.* Galleries of the destructive pine-bark beetle (*Dendroctonus frontalis*) in pine bark: also attacks spruce.
- d.* Work of *Dryocetes picea* Hopk. MS on the surface of spruce wood.
- e.* Galleries of the spruce Polygraphus on surface of pieces of spruce driftwood, found in Parmacheene Lake.



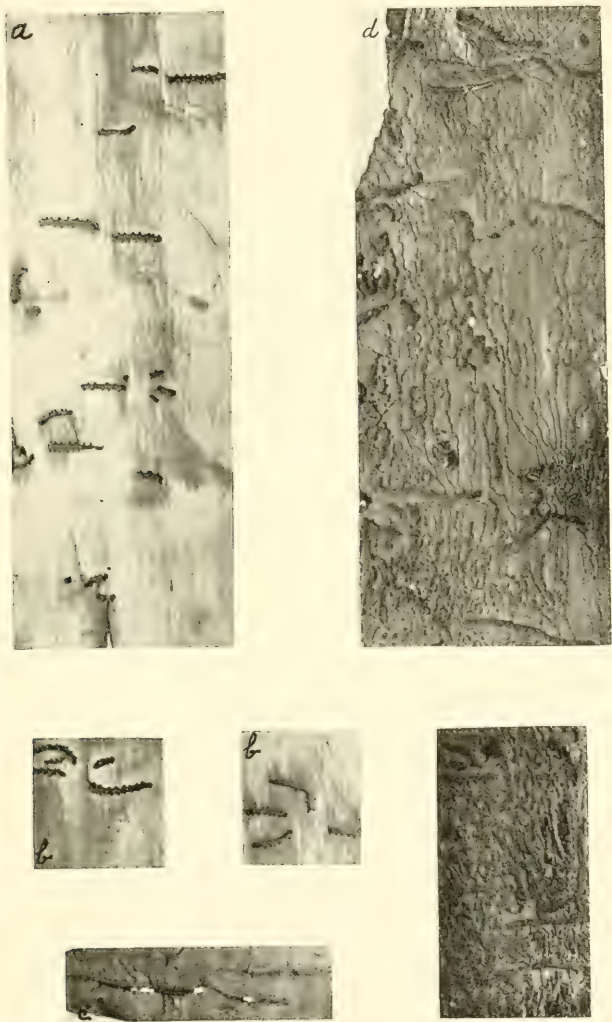
WORK OF SECONDARY AND OTHER ENEMIES OF SPRUCE.

PLATE IX.

Galleries of Polygraphus rufipennis showing different stages.

a, b, c, Freshly excavated galleries in living bark.

d, Old galleries in dead bark.

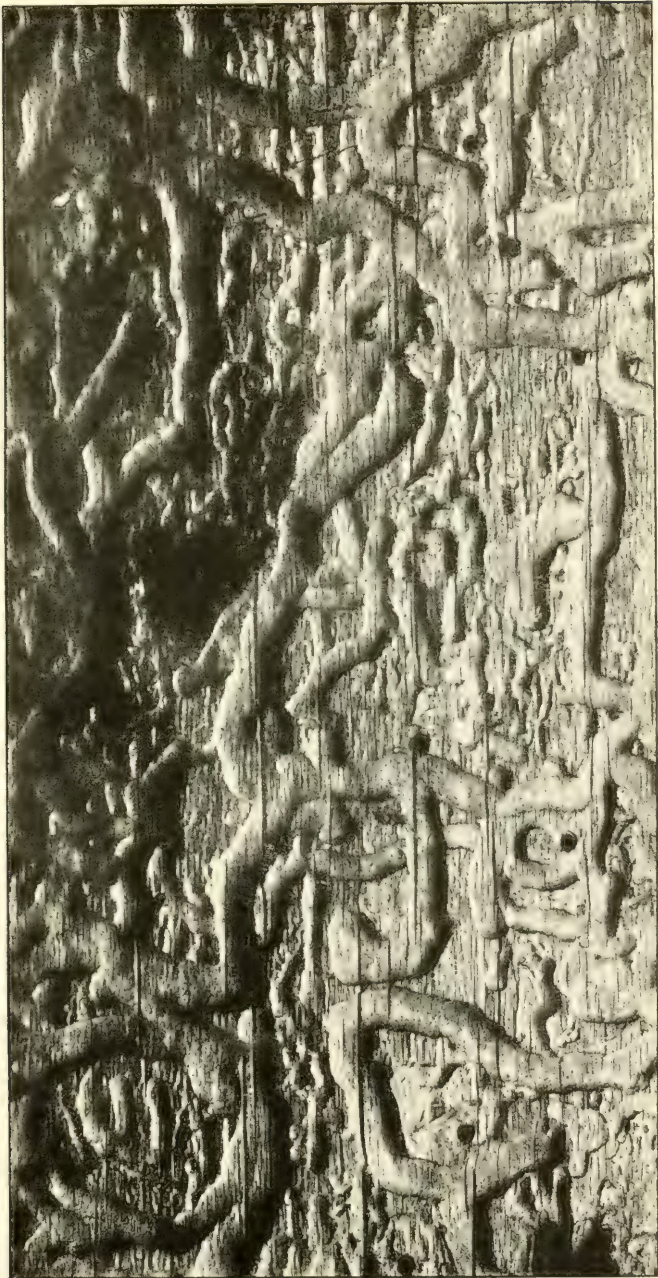


GALLERIES OF *POLYGRAPHUS RUFIPENNIS*, SHOWING DIFFERENT STAGES.

PLATE X.

Mines of Tetropium cinnamopterum.

Surface of the wood of a "peeled" and felled spruce, showing mines made by the spruce Tetropium—natural size.

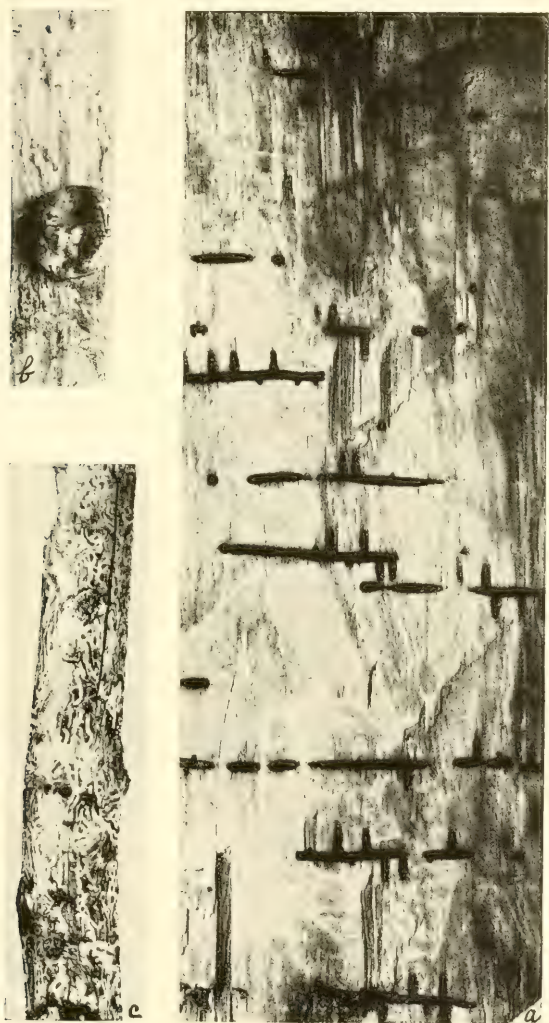


MINES OF *TETROPIUM CINNAMOPTERUM*.

PLATE XI.

Work of Xyloterus bivittatus, and Phloeotribus picea Hopk. MS.

- a.* Work of the wood-mining beetle, *Xyloterus bivittatus*, in the sapwood of spruce—natural size.
- b.* Fungus (*Polyporus volvatus*) growing from mines of *Xyloterus bivittatus* on the surface of the wood after the bark had been removed—natural size.
- c.* Work of *Phloeotribus picea* Hopk. MS. in spruce.



WORK OF *XYLOTERUS BIVITTATUS* AND *PHLOEOTRIBUS*
PICEA HOPK. M. S.

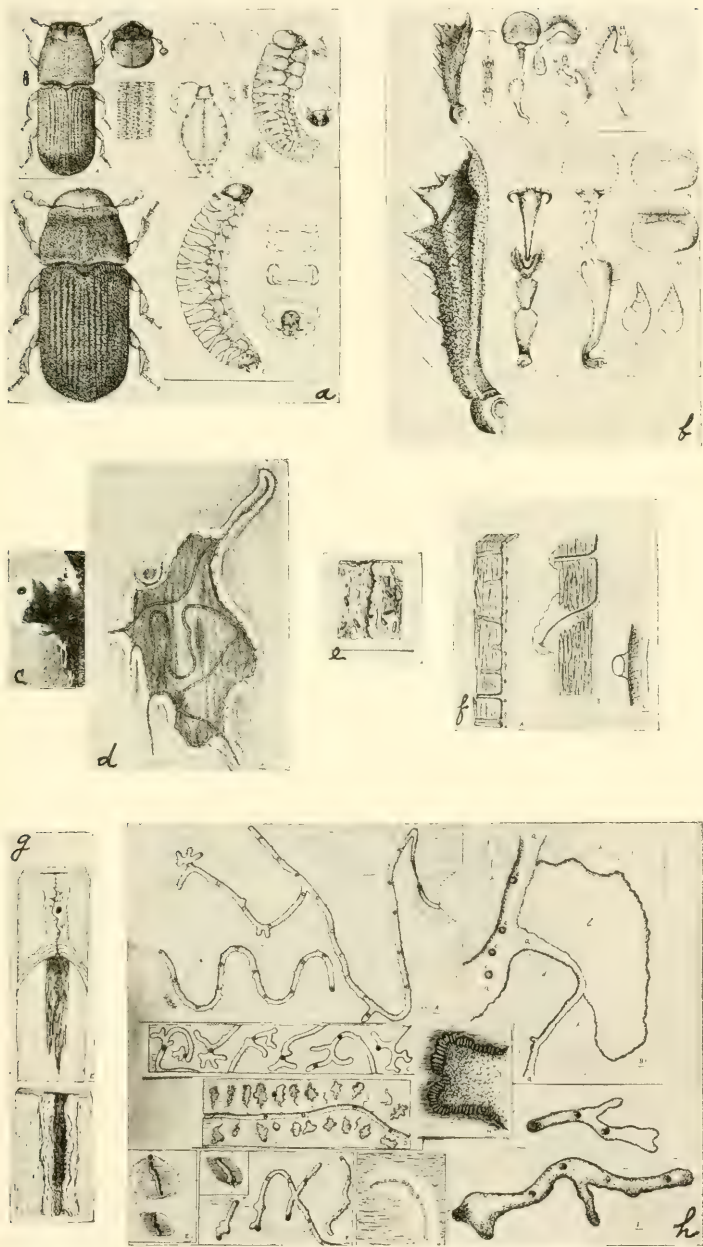
PLATE XII.

Work of Dendroctonus frontalis and Dendroctonus terebrans.

(From drawings illustrating Bulletin 56, W. Va. Agr. Exp. Station.)

- a.* *Dendroctonus frontalis*: *A*, adult; *B*, pupa; *C*, larva; *D*, adult of *Dendroctonus terebrans*; *E*, larva.
- b.* *Dendroctonus frontalis*: *A*, tibia; *B*, tarsus; *C*, *D*, *E*, antennæ; *F*, *G*, mouth parts. *Dendroctonus terebrans*: *H*, tibia; *I*, tarsus; *J*, *K*, *L*, *M*, *N*, antenna—all enlarged.
- c.* Pitch tube made by *Dendroctonus frontalis*—natural size.
- d.* Healing wounds, from living pine tree, made by *D. frontalis*—reduced.
- e.* Pupa cases of *D. frontalis* in outer pine bark.
- f.* *Dendroctonus frontalis*: *A*, *B*, longitudinal section of primary galleries; *C*, egg in egg cavity inside of gallery—the latter enlarged; others reduced.
- g.* Healing wounds in living tree: *E*, *Dendroctonus frontalis*; *F*, *Dendroctonus terebrans*.
- h.* Work of *Dendroctonus frontalis* in pine bark is shown at *A*, *C*, *D*, *E*, *F*, *G*; work of *D. terebrans* in pine bark at *B*, *H*, *I*; larva at work at *H*.

NOTE.—Both *D. frontalis* and *D. terebrans* attack spruce.



WORK OF DENDROCTONUS FRONTALIS AND DENDROCTONUS TEREBRANS.

PLATE XIII.

Top of Black Spruce infested with a caterpillar and a plant-louse. This shows characteristic appearance of the top and cones of the Black Spruce.



TOP OF BLACK SPRUCE INFESTED WITH A CATERPILLAR AND A PLANT LOUSE.

PLATE XIV.

Dead spruce : also fir and birch.

- a*, Old dead spruce and a dead birch in cutting.
- b1*, Remains of very old dead spruce.
- b2*, Appearance of spruce tree after it has been dead five to ten years or more
- c*, White Spruce near gamekeeper's camp. dead three or four years.
- d*, Dead spruce, fir, and birch, killed by fire.
- e*, Dead spruce and fir on summit of Rump Mountain.



DEAD SPRUCE; ALSO FIR AND BIRCH.

PLATE XV.

Timber flooded and killed by water on the Magalloway.

- a* At Camp in the Meadows.
- b,c* Between the dam and the camp.
- c* Also showing the bog spruce growing in the water.

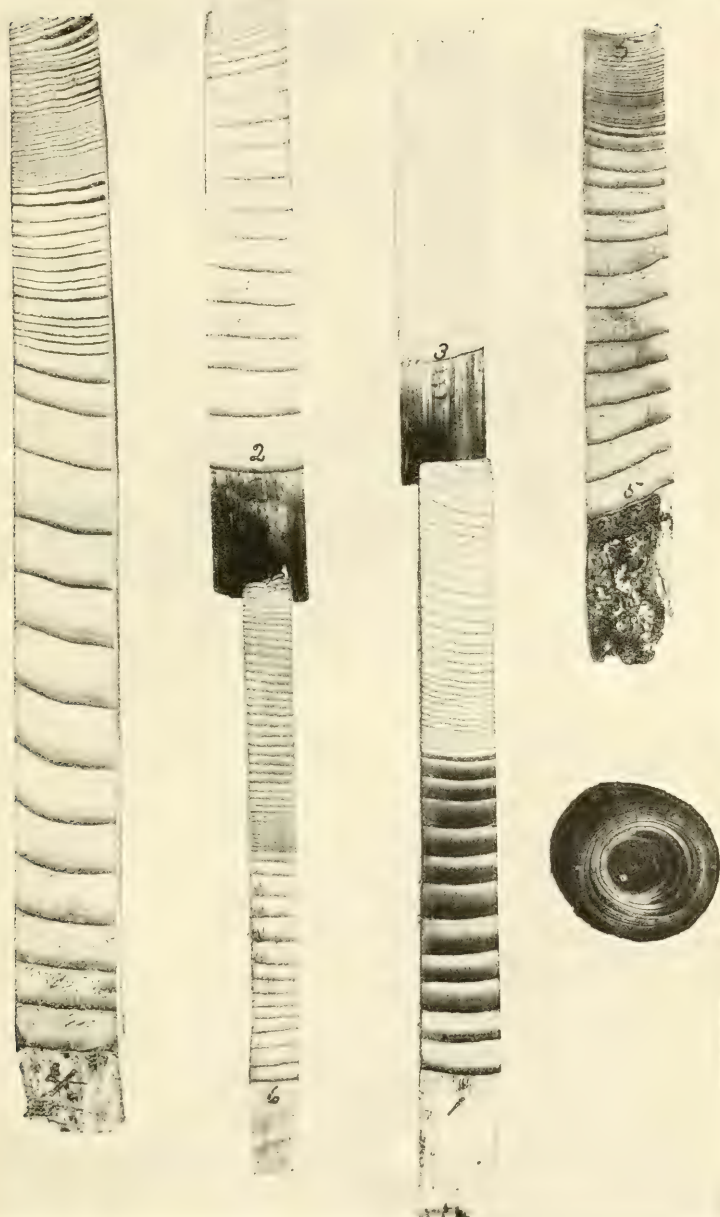


TIMBER FLOODED AND KILLED BY WATER ON THE MAGALLOWAY.

PLATE XVI.

Sections of wood cut from Balsam Fir, showing rapid growth after the old spruces die or are felled.

1. From fir by dead tree in cutting of about 1888.
2. From fir standing by dead spruce in old cutting of about 1886.
3. From fir standing by dead tree that showed the work of the spruce beetle. Tree evidently died about 1888.
4. From fir in blow down of about 1871, which was followed by another in about 1885-86.
5. From fir in blow down of about 1886.
6. From spruce standing by large tree broken by a storm about 1886. Evidence was found in this tree that it was living when felled and that it had been attacked after falling by the spruce beetle. Both galleries and remains of beetles were found in the bark.
7. Section of small suppressed spruce about 45 or 50 years old—all natural size.



SECTIONS OF WOOD CUT FROM BALSAM FIR, SHOWING RAPID GROWTH AFTER THE OLD SPRUCES DIE OR ARE FELLED.



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